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EFFECTS OF SOME ENVIRONMENTAL FACTORS ON YEARLING TRAITS OF COLUMBIA AND TARGHEE EWES

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SELECTION of breeding ewes is often complicated by environmental factors which tend to obscure genetic merit. Correction or adjustment for measurable effects of environmental factors may increase the effectiveness of selection for meat and wool production. These corrections will also be useful in many experimental studies where it is desirable to minimize the complication of environmental effects.

The purpose of this study was to determine the importance of age of dam, type of birth, year of birth, age at shearing, and inbreeding on yearling traits of Columbia and Targhee ewes. The traits studied were staple length, grease fleece weight, body weight, body type, condition (degree of fatness), face covering and neck folds. Breed differences in these traits were also observed.

Data and Methods

The data used in this study were taken on 406 Columbia and 290 Targhee yearling ewes born during the years from 1941 to 1944. Considerable previous selection had been practiced, as about 70 to 80 percent of weanling ewe lambs were usually retained to yearling age. Ewes included in the first 2 years had also been studied as weanlings (Hazel and Terrill, 1946*a*).

Staple length was measured and scores for face covering were taken just prior to shearing by a committee of three men working independently. Fleeces were weighed on the shearing floor and body weights were taken immediately thereafter. Scores for body type, condition and neck folds were taken by a committee of three men a few days after shearing. The scoring system was the same for the four traits evaluated by scoring; ewes having highest merit were given a score of 1 and those having lowest merit a score of 5. Fifteen possible scoring units were obtained by assigning plus or minus values where merit appeared to be slightly above or below the whole unit.

The analysis was carried out as suggested by Yates (1934) for multiple classification tables with unequal numbers, except that the method was extended according to least squares procedure to include age at shearing and percent inbreeding as independent variables (Hazel, 1946). The age at shearing, which averaged 402 days, was used in the analysis as the age at which

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each of the traits was measured. The percent inbreeding ranged from 0 to 36 percent with averages of 10.61 percent for Columbias and 8.35 percent for Targhees. Classifications were made for age of dam (mature and 2-year-old dams), type of birth (singles, twins and twins raised singly), and year of birth (1941 to 1944 inclusive).

Results and Discussion

The means, standard deviations within classes, differences due to age of dam, type of birth, and year, and the regression of each trait on age at shearing and percent inbreeding are summarized in tables 1 and 2. Many of the

TABLE 1. STATISTICS FOR YEARLING TRAITS OF COLUMBIA EWES

Statistic		Staple length	Grease fleece weight	Body weight	Body type	Condition	Face covering	Neck folds
		centimeters	*pounds*	*pounds*	*score*	*score*	*score*	*score*
Mean		9.90	8.72	87.81	2.11	1.97	2.54	1.23
Standard deviation		1.24	1.51	9.73	.27	.30	.48	.20
Mature minus 2-year-old dam		0.46	1.04*	4.16*	−0.074	−0.019	−0.108	0.030
Single minus twin		.12	1.03*	7.12*	− .166*	− .063	− .109*	− .036
Single minus twin raised singly		.44	.58*	2.37*	− .046*	.002	.136*	.010
Deviation from average for year of birth	1941	− .14*	− .37*	−2.52*	.023*	− .022*	.067	.070*
	1942	.06*	− .13*	2.77*	.011*	.018*	− .042	− .023*
	1943	− .54*	− .58*	.87*	− .170*	− .166*	− .067	.013*
	1944	.62*	1.08*	−1.12*	.136*	.170*	.042	− .061*
Regression on age at shearing		.015	.058*	.186*	− .005	− .002	− .005	.002
Regression on percent inbreeding		− .007	− .022	− .055	.002	.002	− .004	.0002

* Signifies that the statistic is large enough to account for 2 percent or more of the total variation in that trait.

differences, although statistically significant, were too small to be important, in that they accounted for relatively small percentages of the total variation. Those large enough to account for two percent or more are designated in tables 1 and 2. Tables 3 and 4 show the mean squares and the percentages of the total variance in each trait which could be attributed to the combined effects of all the factors studied.

Length of Staple

Yearly differences were the most important cause of variation in staple length, accounting for 11 percent of the total variation in Columbias and 9 percent in Targhees. The range of average staple length for the 4 years was 1.16 centimeters for Columbias and 0.81 centimeter for Targhees.

The effect of type of birth on length of staple was more important for Targhees than Columbias. In each breed twins had longer staple than twins

raised singly. This was also true of Rambouillets at weanling and yearling age and of Columbias and Targhees at weanling age (Hazel and Terrill 1945, 1946*b* and 1946*a*). These differences may have been caused by a more favorable environment for length of staple for twins raised as twins as they were run in a separate band until weaning during 3 of the 4 years. Differences between singles and twins in staple length might be increased if they were run in the same band till weaning.

TABLE 2. STATISTICS FOR YEARLING TRAITS OF TARGHEE EWES

Statistic	Staple length	Grease fleece weight	Body weight	Body type	Condition	Face covering	Neck folds
	centimeters	*pounds*	*pounds*	*score*	*score*	*score*	*score*
Mean	8.18	7.95	77.88	2.29	2.12	3.86	1.39
Standard deviation	1.04	1.23	5.41	.36	.29	.66	.26
Mature minus 2-year-old dam	−0.03	0.48*	0.60	0.007	0.052	0.103	0.081
Single minus twin	.45*	.85*	4.70*	− .089*	− .052*	.106	.002
Single minus twin raised singly	.53*	.63*	7.42*	− .196*	− .146*	− .023	.017
Deviation from average for year of birth: 1941	− .26*	− .52*	−4.61*	.089*	.049*	.143	.176*
1942	− .09*	− .29*	.26*	− .095*	−. 038*	− .050	− .018*
1943	− .20*	− .11*	2.62*	− .068*	− .117*	− .037	− .028*
1944	.55*	.92*	1.73*	.074*	.106*	− .056	− .130*
Regression on age at shearing	.028	.061*	.296*	− .012*	− .007*	− .012	− .001
Regression on percent inbreeding	− .006	− .032*	− .387*	.011*	.006*	.002	.001

* Signifies that the statistic is large enough to account for 2 percent or more of the total variation in that trait.

Accuracy of selection for staple length may be increased by adjusting for years and type of birth. Age of dam, age at shearing, and inbreeding did not have an important effect on length of staple.

Grease Fleece Weight

Each factor studied had a significant effect upon grease fleece weight in each breed. Differences in environment between years were the most important source of variation, accounting for 16 and 14 percent of the total variation in Columbias and Targhees, respectively. The range in average grease fleece weight for the 4-year period was 1.66 pounds for Columbias and 1.44 pounds for Targhees.

Daughters of mature ewes sheared about 1 pound more than daughters of 2-year-old ewes in Columbias and about ½ pound more in Targhees. Grease fleece weights of single ewes were heavier than those of twins, the average difference being 1.03 and 0.85 pounds for Columbias and Targhees respectively. Grease fleece weights for twins raised singly were intermediate but were closer to the twins than the singles.

Age at shearing accounted for about 5 percent of the total variation of grease fleece weight in both breeds. The average change for each day's increase in age was 0.058 pound for Columbias and 0.061 pound for Targhees as indicated by the regression coefficients. These were much greater than the

TABLE 3. SUMMARY OF ANALYSIS OF VARIANCE FOR EACH OF THE YEARLING TRAITS OF COLUMBIA EWES

Source of variation	Degrees of freedom	Mean squares						
		Staple length	Grease fleece weight	Body weight	Body type	Condition	Face covering	Neck folds
Total	405	1.77	3.14	106	.09	.11	.23	.04
Age of dam	1	14.24*	71.68**	1142**	.36*	.02	.76	.06
Type of birth	2	3.42	34.39**	1579**	.86**	.14	1.05*	.05
Year of birth	3	27.02**	67.36**	463**	1.77**	2.21**	.38	.31**
Age at shearing	1	4.18	63.06**	655**	.45*	.05	.51	.09
Percent inbreeding	1	1.30	12.58*	75	.10	.12	.33	.002
Within main classes	397	1.54	2.27	95	.08	.09	.23	.04
Percent of total variation accounted for		15	29	12	20	16	4	7

* Signifies probability of chance occurrence <.05.
** Signifies probability of chance occurrence <.01.

TABLE 4. SUMMARY OF ANALYSIS OF VARIANCE FOR EACH OF THE YEARLING TRAITS OF TARGHEE EWES

Source of variation	Degrees of freedom	Mean squares						
		Staple length	Grease fleece weight	Body weight	Body type	Condition	Face covering	Neck folds
Total	289	1.26	2.20	55	.13	.10	.44	.08
Age of dam	1	.03	10.37**	16	.002	.12	.48	.29*
Type of birth	2	6.92**	18.96**	1030**	.60**	.32*	.34	.004
Year of birth	3	10.44**	29.61**	618**	.65**	.69**	.56	1.04**
Age at shearing	1	6.91*	33.50**	778**	1.37**	.46*	1.27	.02
Percent inbreeding	1	.54	15.80**	2346**	1.75**	.57**	.06	.02
Within main classes	281	1.08	1.51	29	.13	.08	.44	.07
Percent of total variation accounted for		17	33	48	14	16	3	14

* Signifies probability of chance occurrence <.05.
** Signifies probability of chance occurrence <.01.

regression coefficient for Rambouillets of 0.026 pound (Hazel and Terrill, 1946b) and also were much greater than the average daily growth from birth to shearing of 0.022 and 0.020 pound for Columbias and Targhees, respectively.

There was a significant decrease in grease fleece weight with increasing percent of inbreeding in both breeds. The average decrease as indicated by regression coefficients was −0.022 and −0.032 pound for Columbias and Targhees respectively.

The effect of each factor on grease fleece weights was of sufficient importance to warrant adjustment before making selections based on yearling records.

Body Weight

Type of birth had an important effect on body weight, accounting for 7 and 13 percent of the total variation in Columbias and Targhees, respectively. Columbia single ewes weighed 7.12 pound more than twins and 2.37 pounds more than twins raised singly. The corresponding differences for Targhees were 4.70 and 7.42 pounds, respectively. The body weights of Targhee twins raised as singles are smaller than would be expected, as the deviation from singles is greater than at weanling age (Hazel and Terrill, 1946*a*) and is also greater than the corresponding difference of 0.5 pound for Rambouillet yearling ewes (Hazel and Terrill, 1946*b*). With this exception the effect of type of birth on yearling weight is in the same direction but smaller than for weanlings (Hazel and Terrill, 1946*a*). Phillips and Dawson (1940), working with farm sheep, found that differences in weight due to type of birth tended to disappear at 12 months of age. However, Phillips *et al.* (1940), working with range sheep, found that singles were heavier than twins, on the average, throughout the first year.

Age of dam had an important effect on body weight in Columbias but its effect, though positive, was not significant in Targhees. Differences in environmental influences between years were an important source of variation in body weight for both breeds. The range of average body weights for the 4-year period was 7.23 pounds for Targhees and 5.29 pounds for Columbias.

Body weight was definitely influenced by age at shearing. The average change per day was 0.186 and 0.296 pound for Columbias and Targhees, respectively. These were much less than the weanling regressions (Hazel and Terrill, 1946*a*) but were much greater than the average daily growth from weanling to yearling age. This indicates that an appreciable part of the differences in weight due to age at weaning time is still present at yearling age. This was not true of Rambouillets (Hazel and Terrill, 1946*b*).

The regression coefficient of body weight on inbreeding of −0.387 for Targhees was highly significant and was slightly larger than the weanling regression for Targhees and the weanling and yearling regression for Rambouillets (Hazel and Terrill, 1945, 1946*a*, 1946*b*).

The results indicate that yearling body weights used for selection should first be adjusted for each of the environmental factors studied. These factors had a greater effect on Targhee body weight than on any of the other traits studied, accounting for 48 percent of the total variation. Their effect on Columbia body weight was much less important, accounting for 12 percent of the total variation.

Body Type

Type of birth had an important effect on body type in both Columbia and Targhees. Differences were in the same order and direction as those for body weight. In Columbias, single lambs had better type than twin lambs while twins raised as singles were intermediate. In Targhees singles were superior to twins but twins raised as singles had poorer type than twins.

Yearly variation in body type scores was important in both breeds although Columbias were more variable between years than Targhees. Age of dam did not have an important effect on body type in either breed. Body type score improved with age at shearing and became poorer with inbreeding in both breeds. These effects were larger for Targhees than for Columbias.

Adjustments for environmental effects on body type score are advisable for years, type of birth, age at shearing, and inbreeding.

Condition

Years were the most important source of variation in condition score, accounting for 15 and 8 percent of the total variation in Columbias and Targhees respectively. Age of dam was not important in either breed.

Type of birth was important for Targhees but not for Columbias. Differences in Targhee condition scores due to type of birth were smaller but in the same order and direction as for type score. Changes in condition score due to age and inbreeding were similar to those in type score but were generally smaller.

Adjustment of condition score is most important for years. In Targhees type of birth, age at shearing, and inbreeding each accounted for about 2 percent of the total variance and some gain in accuracy of selection might be made by adjusting for these factors.

Face Covering

Face covering was least affected by the environmental factors of any of the traits. The percent of the total variation accounted for by the factors studied was 4 percent for Columbias and 3 percent for Targhees. Type of birth accounted for 2 percent of the total variation in Columbias. Environ-

mental factors studied might well be disregarded in selecting for open face in yearling Columbia and Targhee ewes.

Neck Folds

Neck folds were affected less by environmental factors studied than any of the traits except face covering. Most of the variation accounted for in neck folds could be attributed to years. There was a trend in both breeds toward increasing smoothness although the trend was more consistent in the Targhees where slightly more folds are present than in Columbias. It seems probable that these trends are in part due to genetic change because selection for absence of neck folds is being practiced in each of these breeds.

Breed Differences

Columbia yearling ewes excelled Targhees in each trait studied. This was also true of weanling lambs (Hazel and Terrill, 1946*a*). Differences appeared to be smallest for type and condition scores and were greatest for face covering and length of staple. In general the environmental factors studied had a greater total effect on Targhee than on Columbia traits. This was particularly true of inbreeding and age at shearing.

Summary

The effects of age of dam, type of birth, year of birth, age at shearing and percent inbreeding on staple length, grease fleece weight, body weight, type, condition, face covering and neck folds were studied on 406 Columbia and 290 Targhee yearling ewes at the U. S. Sheep Experiment Station, Dubois, Idaho. The ewes were born during the years 1941 to 1944.

The effect of the environmental factors was greatest on fleece weight and body weight and least on face covering and neck folds. Year of birth was the most important environmental source of variation followed by type of birth, age at shearing, and percent inbreeding. Age of dam was the least important source of variation of Columbia and Targhee yearling traits.

Single ewes had heavier bodies and fleeces, longer staple and better type and condition than twins. Daughters of mature dams had heavier fleeces and bodies than those of 2-year-old dams. Fleece and body weights, staple length, type and condition improved with age at shearing and became poorer with inbreeding.

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SEASONAL VARIATIONS IN THE OCCURRENCE OF CONCEPTIONS IN KARAKUL SHEEP

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THE seasonal nature of the breeding season in many breeds of sheep is well established. Most ewes begin coming in estrus in late summer or early fall. If not bred, they continue to exhibit estrus at intervals of approximately 16 to 17 days, on the average, until some time during the winter or early spring. Some breeds tend to exhibit estrus earlier in the fall than do others, and continue to undergo estrous cycle until later in the winter or spring. Some ewes in certain breeds may exhibit estrus during the spring and early summer months. Literature bearing on these points is reviewed by McKenzie and Terrill (1937) and Phillips, Fraps and Frank (1945).

The Karakul breed is one of those in which many ewes generally are reputed to exhibit estrus during the spring and early summer, and from which two crops of lambs per year, or three in two years, frequently can be obtained. Some investigations have been made on this point. Loginova (1939) observed spontaneous ovulation in Karakul ewes during the summer, but it was not accompanied by estrus. Forced mating during periods of silent estrus in fat-tailed Merino and Karakul ewes resulted in conceptions in 6 percent of the cases. Pomanskii and Stojanovskaja (1936) studied 500 Karakul ewes that were 3 to 6 years of age, in Uzbekistan, that were run with rams during the period May 25 to August 13. In the autumn, 78.3 percent of the ewes lambed. Those workers concluded that Karakuls may breed at all times of the year under Uzbekistan conditions.

There is an indication that Karakul sheep do not mate freely throughout the year in the United States. Schott, Phillips and Spencer (1939) did not observe estrus in any Karakul and high-grade Karakul ewes at Beltsville, Maryland from three days after each ewe lambed in the spring until middle or late August, during 1938.

The study reported in this paper was designed to obtain additional information on the seasonal nature of breeding in Karakul sheep.

Materials and Methods

The Karakul and grade Karakul flocks at the Agricultural Research Center, Beltsville, Maryland were last bred in the fall of 1941 for regular lambing. Mating began in August and ended in October. After July, 1942 the ewes were kept with rams at all times so that mating could take place when-

[1] Bureau of Animal Industry, Washington 25, D. C., and Beltsville, Md.

ever estrus occurred. This practice continued until March 31, 1946. Therefore, lambs from matings within this period could have been dropped from about December 1, 1942 to August 31, 1946. Dates of birth were known for all lambs born during this period. These dates form the basis for this study,

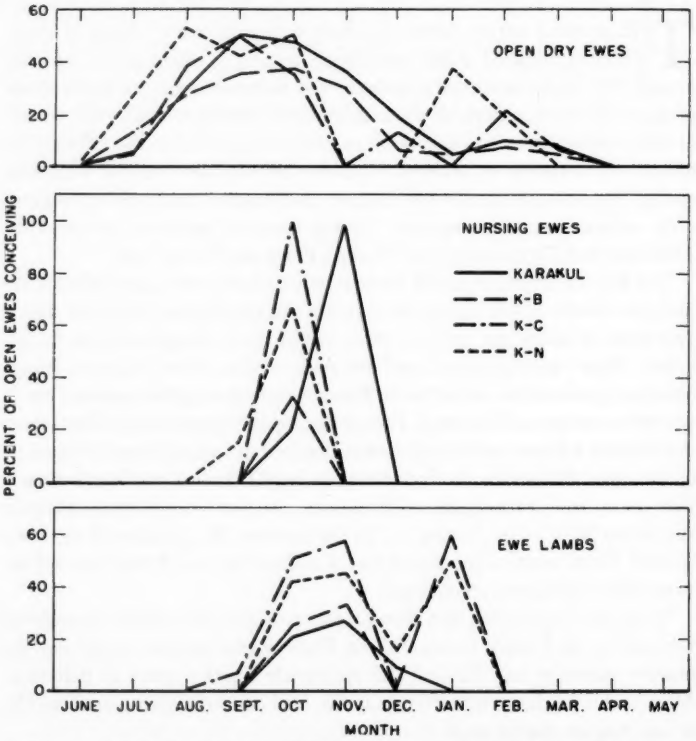

Figure 1. Graph showing the distributions of conceptions, by months, among dry and nursing ewes, and ewe lambs in the four groups studied. The symbols K-B, K-C, and K-N refer to animals carrying some Blackfaced Highland, Corriedale, and Navajo blood, respectively.

the time of conception presumably being about five months earlier in each case.

The data were compiled in three categories, by months, in which open individuals were exposed to rams, as follows: (1) Ewes over 12 months of age that were open, either because they had not yet conceived, or if they had completed a pregnancy, the offspring had been killed for pelting (usually

TABLE 1. SUMMARY OF DATA ON INCIDENCE OF PREGNANCY, BY MONTHS, IN KARAKUL AND KARAKUL-GRADE EWES

Item	Month											
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Karakul ewes												
No. dry ewes	79	128	137	103	52	33	21	24	52	86	69	78
No. conceived	0	8	42	52	25	12	4	1	5	7	0	1
Percent conceived	0	6.2	30.6	50.5	48.1	36.4	19.0	4.2	9.6	8.1	0	1.3
No. nursing ewes	32	17	10	7	5	1	—	2	18	30	29	30
No. conceived	0	0	0	0	1	1	—	0	0	0	0	0
Percent conceived	0	0	0	0	20.0	100.0	—	0	0	0	0	0
No. lambs	4	15	15	17	19	11	12	10	9	7	3	3
No. conceived	0	0	0	0	4	3	1	0	0	0	0	0
Percent conceived	0	0	0	0	21.0	27.2	8.3	0	0	0	0	0
K-B ewes												
No. dry ewes	45	65	64	48	32	20	17	23	34	44	36	42
No. conceived	0	8	18	17	12	6	1	1	3	2	0	0
Percent conceived	0	12.3	28.1	35.4	37.5	30.0	5.9	4.3	8.8	4.5	0	0
No. nursing ewes	14	11	9	4	3	2	1	1	9	14	13	16
No. conceived	0	0	0	0	1	0	0	0	0	0	0	0
Percent conceived	0	0	0	0	33.3	0	0	0	0	0	0	0
No. lambs	4	11	12	14	16	12	7	5	2	2	1	1
No. conceived	0	0	0	0	4	4	0	3	0	0	0	0
Percent conceived	0	0	0	0	25.0	33.0	0	60.0	0	0	0	0
K-C ewes												
No. dry ewes	58	83	89	52	28	17	15	21	42	49	48	51
No. conceived	0	5	34	26	10	0	2	0	9	3	0	0
Percent conceived	0	6.0	38.2	50.0	35.7	0	13.3	0	21.4	6.1	0	0
No. nursing ewes	10	4	2	3	2	2	1	—	13	30	17	17
No. conceived	0	0	0	0	2	0	0	—	0	0	0	0
Percent conceived	0	0	0	0	100.0	0	0	—	0	0	0	0
No. lambs	—	12	13	14	14	7	3	2	2	1	—	—
No. conceived	—	0	0	1	7	4	0	0	0	0	—	—
Percent conceived	—	0	0	7.1	50.0	57.1	0	0	0	0	—	—
K-N ewes												
No. dry ewes	31	44	41	14	10	8	8	16	20	19	20	25
No. conceived	0	12	22	6	5	0	0	6	4	0	0	0
Percent conceived	0	27.3	53.6	42.8	50.0	0	0	37.5	20.0	0	0	0
No. nursing ewes	13	15	14	13	9	—	—	3	15	19	18	18
No. conceived	0	0	0	2	6	—	—	0	0	0	0	0
Percent conceived	0	0	0	15.4	66.7	—	—	0	0	0	0	0
No. lambs	4	10	13	16	17	11	7	6	3	4	4	3
No. conceived	0	0	0	0	7	5	1	3	0	0	0	0
Percent conceived	0	0	0	0	41.2	45.4	14.3	50.0	0	0	0	0

within one or two days after birth) or had died from other causes; (2) ewes that were nursing lambs; and (3) ewe lambs that were six to twelve months of age, inclusive.

The breed groups indicated by the symbols K-B, K-C, and K-N carry, in addition to Karakul blood, some Blackfaced Highland, Corriedale, and Navajo

TABLE 2. CONCEPTIONS, BY MONTHS, IN ALL EWES STUDIED

Month	Open ewes exposed to rams (number)			Ewes conceived (percent)		
	Dry ewes	Nursing ewes	Ewe lambs	Dry ewes	Nursing ewes*	Ewe lambs
June	213	69	12	0.0	0.0	0.0
July	320	47	48	10.3	0.0	0.0
Aug.	331	35	53	35.0	0.0	0.0
Sept.	217	27	61	46.5	7.4	1.6
Oct.	122	19	66	42.6	52.6	33.3
Nov.	78	5	41	23.1	20.0	39.0
Dec.	61	2	29	11.5	0.0	6.9
Jan.	84	6	23	9.5	0.0	26.1
Feb.	148	55	16	14.2	0.0	0.0
Mar.	198	83	14	6.1	0.0	0.0
Apr.	173	77	8	0.0	0.0	0.0
May	196	81	7	0.5	0.0	0.0

* These are ewes that were actually nursing lambs.

blood, respectively. The amounts of Blackfaced Highland and Corriedale blood were quite low, being 1/16 or less, with the exception of two K-C ewes that had $\frac{1}{8}$ Corriedale blood. The proportion of Navajo blood was higher, varying from $\frac{1}{8}$ to $\frac{1}{2}$.

Results and Discussion

Seasonal Variations in Rate of Conception

Data on the occurrence of conceptions in the various groups are summarized, by months, in tables 1 and 2, and a graphic summary of percentages of conceptions among open ewes exposed to rams is given in figure 1.

There appear to be no major differences among the four breed-groups in the incidence of conceptions at various times during the year, other than small variations that might be due to limited numbers under observation in some of the months.

Distinct differences appear, between dry and nursing ewes, in the incidence of conceptions by months. There were 13 conceptions while ewes were nursing lambs, and all these occurred during September, October, and

November, which is during or just past the peak of normal breeding activity in dry ewes (see figure 1). Thus, it appears that nursing ewes have a limited breeding season in comparison with dry ewes, among which conceptions occurred in all months except April and June.

The months of greatest breeding activity among dry ewes were August, September, and October. During subsequent months there was, in general,

TABLE 3. INTERVALS FROM LAMBING AND WEANING, RESPECTIVELY, TO CONCEPTION IN DRY AND NURSING EWES

Breeding of animal	No. and interval	Month of conception											
		June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Interval from lambing to conception in dry ewes													
	No.	—	6	20	36	13	5	—	—	5	6	—	1
Karakul	Interval	—	190.5	146.2	172.3	203.5	262.2	—	—	162.8	42.0	—	156.0
	No.	—	4	10	11	6	4	1	—	3	2	—	—
K-B	Interval	—	180.2	170.5	164.9	197.5	200.2	317	—	42.0	58	—	—
	No.	—	5	19	18	6	—	1	—	8	4	—	—
K-C	Interval	—	188.4	172.4	161.3	146.7	—	154	—	41.4	37.8	—	—
	No.	—	4	11	4	1	—	—	4	6	—	—	—
K-N	Interval	—	147.2	132.6	150.8	193	—	—	98.5	44.5	—	—	—
	No.	—	19	60	69	26	9	2	4	22	12	—	1
All ewes	Interval	—	178.7	156.0	167.0	188.6	234.7	235.5	98.5	69.9	43.2	—	156.0
Interval from weaning to conception in nursing ewes[1]													
	No.	—	—	10	14	10	4	1	1	—	—	—	—
Karakul	Interval	—	—	60.3	96.5	78.5	88.8	77.0	261.0	—	—	—	—
	No.	—	2	1	7	4	1	—	—	—	—	—	—
K-B	Interval	—	59.0	94.0	69.4	138.8	89.0	—	—	—	—	—	—
	No.	—	—	8	7	4	—	—	—	—	—	—	—
K-C	Interval	—	—	51.8	126.6	106.2	—	—	—	—	—	—	—
	No.	—	6	8	2	4	—	—	2	—	—	—	—
K-N	Interval	—	59.0	50.6	38.0	48.2	—	—	70.0	—	—	—	—
	No.	—	8	27	30	22	5	1	3	—	—	—	—
All ewes	Interval	—	59.0	56.1	93.3	89.0	88.8	77.0	133.7	—	—	—	—

[1] These are ewes that had nursed lambs, and conceived after lambs were weaned. Thirteen ewes conceived during October and November, while nursing. See text for details.

a tapering off in the percentage of conceptions among dry ewes, to a very low level during May, with no conceptions during April and June.

Conceptions in lambs of from 6 to 12 months of age occurred during the months of September to January, inclusive. The reason for the bimodal nature of the distribution (see figure 1), with a low point in December between high points in November and January, is not clear, other than chance deviations in the data, particularly in December and January when numbers were rather small.

Intervals from Lambing or Weaning to Conception

Data on intervals from lambing or weaning to conception are presented in table 3.

The major portion of the dry ewes conceived by the end of October (during July, August, September, and October) and these ewes had lambed, on the average, about 5 to 6 months earlier. The dry ewes that conceived during November and December had lambed about eight months earlier. Thus, most of the ewes unincumbered by nursing lambs apparently had an extended anestrus following lambing, and conceived again during the fall breeding season. Ewes that conceived during January, February, and March were, on the average, those that had lambed about 1.5 to 3 months earlier, or during the late fall and early winter months. One ewe that conceived in May had lambed during December. These conceptions following fall and early winter lambings account for the relatively high percentages of conceptions during the winter months, in the curves for two groups of dry ewes which are presented in figure 1.

All the ewes that conceived after nursing lambs did so during the months of July to January, inclusive. None conceived during February to June, inclusive. Thus, it appears that there was a more limited breeding season among such ewes than among ewes that had not had the burden of lactation, since most of the conceptions occurred during August, September, and October, with a few in July and in the three months (Nov., Dec., Jan.) immediately following the peak period of sexual activity in dry ewes. In most of the groups of nursing ewes, summarized by months in table 3, conception occurred on the average about 2 to 3 months after the end of lactation, or about 7 to 8 months after the previous lambing. So, like the major portion of the dry ewes, most of these ewes were conceiving in the fall, following lambings in the preceding late winter or spring. Among the 13 ewes that conceived while nursing lambs, conception occurred from 61 to 139 days after lambing, and at an average of 102 days. Lambs were weaned at 140 days. All these conceptions occurred during September, October and November, hence were cases in which lambs had been dropped prior to or during the main breeding season and conception occurred during the months when sexual activity was highest.

The tendency of ewes that lamb in the fall to conceive again relatively soon, in contrast with the longer interval from lambing to conception among ewes that lamb in the late winter and spring months, appears to reflect two things. First, it seems probable that these ewes may have a longer-than-average breeding season, since they had already demonstrated their ability to conceive outside the limits of the usual breeding season. Second, since

they did lamb in the fall, there was opportunity for them to conceive again before the low point of quiescence during April, May, and June.

Annual Rates of Conception

It is difficult to arrive at a single figure that indicates the rate of conception per year in a flock, since the numbers of animals of breeding age shift from month to month, the main breeding season extends over several months, and animals vary in their treatment, some having lambs pelted, others nursing lambs, etc. However, a close approximation of conception rates can be had by relating the average interval from lambing to conception plus the average gestation period (149 days) to the number of days in a year. Among dry ewes that conceived, the interval from lambing to conception (153.5 days) plus the gestation period totaled 302.5. Days in a year, divided by this figure, gives an average of 1.2 lambings per year among dry ewes.

The same type of figure can be had for nursing ewes, by adding the period of pregnancy and the average period from lambing to conception (204.6), obtaining a total of 353.6. Days in a year, divided by this figure, gives an average of 1.03 conceptions per year among ewes that nursed lambs. This includes ewes that conceived while nursing lambs and that conceived after lambs were weaned at 140 days of age.

The above figures actually cover four breeding years, since observations began just at the close of the April–May–June anestrus in 1942, and ended just prior to this period in 1946.

The above figures, like those on seasonal variations in rate of conception, indicate that possibilities of getting two lamb crops per year are limited to about 20 percent of the ewes that do not nurse lambs and 3 percent of those that do.

Age of Ewes at First Conception

Wide variations were observed in the age at first conception, among the ewes that became pregnant for the first time during the course of the experiment. Data were available on 86 animals (see table 4) and the age varied from 7 to 33 months, and averaged 14 months. Examination of the distribution of conceptions in table 4 brings out the point that ewe lambs (6 to 12 months of age) conceived chiefly during October to January inclusive, while most of the ewes did not conceive until after one year of age but did so during August–October, inclusive. It is possible that some ewes that did not conceive until nearly two years of age or later might have done so earlier if management practices had been more favorable for their development. Because of a limited number of pastures, it was necessary to keep ewe lambs and young ewes with older ewes, and this unfavorable competition naturally

limited their development somewhat. Work by Phillips *et al.* (1945) has indicated that rate of development between 6 and 12 months affects the sexual development of the ewe and her breeding performance when bred at about 18 months of age.

TABLE 4. DISTRIBUTIONS OF AGES OF FIRST CONCEPTION IN EWES, BY AGES AND MONTHS OF CONCEPTION, THAT CONCEIVED FOR FIRST TIME DURING THE EXPERIMENT

Age (months)	Month of conception												Totals
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	
7	—	—	—	—	2	—	—	1	—	—	—	—	3
8	—	—	—	1	4	—	—	—	—	—	—	—	5
9	—	—	—	—	11	7	—	1	—	—	—	—	19
10	—	—	—	—	2	12	2	3	—	—	—	—	19
11	—	—	—	—	1	—	1	1	—	—	—	—	3
12	—	—	—	—	—	—	1	1	—	—	—	—	2
13	—	—	2	1	—	—	—	—	—	—	—	—	3
14	—	—	—	2	1	—	—	—	—	—	—	—	3
15	—	—	—	—	—	—	—	—	—	—	—	—	0
16	—	1	2	—	—	—	—	—	—	—	—	—	3
17	—	—	1	—	—	—	—	—	—	—	—	—	1
18	—	—	2	2	1	—	—	—	—	—	—	—	5
19	—	—	2	2	—	—	—	—	—	—	—	—	4
20	—	—	—	1	1	—	—	—	—	—	—	—	2
21	—	—	1	—	—	1	—	—	—	—	—	—	2
22	—	—	—	—	—	1	—	—	—	—	—	—	1
23	—	—	—	—	—	—	1	1	—	—	—	—	2
24	—	—	—	—	—	—	—	1	—	—	—	—	1
27	—	—	—	—	1	—	—	—	—	—	—	—	1
28	—	—	1	—	—	—	—	—	—	—	—	—	1
29	—	—	1	1	—	—	1	—	—	—	—	—	3
30	—	—	—	1	—	—	—	—	—	—	—	—	1
32	—	—	—	1	—	—	—	—	—	—	—	—	1
33	—	—	—	—	—	1	—	—	—	—	—	—	1
Totals	0	1	12	12	24	22	6	9	0	0	0	0	86

Discussion and Application of Results

The data obtained during this study shows that, under conditions at Beltsville, Maryland, Karakul and high-grade Karakul ewes have a definite breeding season in the fall and early winter and that most of them have an anestrous period during the late winter, spring and early summer months, and especially during April, May and June. There is a tendency for ewes that lamb in the fall (and have lambs pelted) to conceive again during the winter, thus making it possible to obtain two lamb crops per year in some cases. However, the number of ewes that conceive to lamb in the fall is

small, and under our conditions the difficulties of management imposed by having an unlimited breeding season are such as to offset the limited advantage gained by having a few ewes lamb twice yearly. Consequently, beginning with the 1946 breeding season, we returned to a limited breeding season with matings beginning about September 4, 1946.

It is possible that more favorable results might be obtained under other conditions, such as at lower latitudes. Work noted by Marshall (1936) has indicated that seasonal breeding animals, such as sheep and deer, quickly become adapted to the new seasonal rhythm when transferred from the northern to the southern hemisphere. We lack concrete evidence on the relation of latitude within a hemisphere to the breeding season in sheep, but there is some evidence in the work of Schott, Phillips, and Spencer (1939) and Whitehurst *et al.* (1947) that it may be longer in the lower latitudes than it is farther north where seasonal changes in climate are more marked.

Summary

An experiment was conducted at Beltsville, Maryland, to determine the extent of the breeding season in Karakul and grade Karakul sheep and the possibilities of obtaining more than one lamb crop per year. The females of all ages were kept with rams at all times for nearly four years (July 1, 1942 to March 31, 1946).

Conceptions among non-nursing (lambs pelted) and otherwise dry ewes occurred chiefly during August to November, with a peak of sexual activity in September and October. A small portion (10.3 percent) of the ewes exposed to breeding in July conceived, and similar proportions conceived among those exposed during December, January, and February. Few ewes conceived in March, only one in May, and none during April and June.

Only 13 ewes conceived while nursing lambs and these conceptions occurred during September, October, and November, during and just after the peak of sexual activity in non-nursing ewes.

Some conceptions occurred among ewe lambs between the ages of 7 and 12 months and all of these took place during September to January, inclusive.

A study of intervals from lambing to conception showed that most ewes whose lambs were born in the spring, and pelted, did not conceive again until the following fall. The same was true of ewes that nursed lambs, for they conceived about 2 to 3 months after weaning or 7 to 8 months after lambing, on the average. The average interval between lambing and conception was much shorter among ewes that conceived during January, February, and March, indicating a tendency for ewes that lambed in the fall and early winter (and whose lambs were pelted) to conceive again before the anestrous period that characterized the flock during April, May, and June.

The rates of conception per ewe per year, calculated from days from lambing to conception plus duration of pregnancy, in relation to days per year, were 1.2 for ewes that did not rear lambs, and 1.03 for ewes that nursed lambs.

Age of ewe at first conception varied from 7 to 33 months and averaged 14. Most ewes that conceived under one year of age did so during October to January, while those that conceived for the first time at later ages were more apt to do so during August to October.

The data indicate that, under conditions at Beltsville, Maryland, the possibilities of obtaining an extra lamb crop per year from Karakul and grade Karakul ewes are very limited.

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RELATION OF KEMP AND OTHER MEDULLATED FIBERS TO AGE IN THE FLEECES OF NAVAJO AND CROSSBRED LAMBS[1]

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Introduction

THE foundation flock of sheep at the Southwestern Range and Sheep Breeding Laboratory, Ft. Wingate, N. Mex. consisted of about 800 old-type Navajo ewes and rams. The breeding program has been conducted along two main lines: (1) Selection and improvement within the Navajo strain; (2) Crossbreeding of Navajo ewes with purebred rams of white-faced breeds, particularly the Romney and Corriedale breeds, followed by selection and linebreeding of the offspring. The objective of this program is the development of an improved type of sheep that will be well adapted to southwestern range conditions, and will produce a good feeder lamb, and a fleece of wool suitable for Navajo hand weaving as well as for commercial manufacture. A quarter-blood type of wool that is free or relatively free from kemp and other medullated fibers meets these requirements.

Wool improvement has received primary emphasis in the breeding program, because of its importance in the economy of the Navajo Indians. The old-type Navajo sheep have a hairy fleece containing varying amounts of kemp and other coarse medullated hair fibers. The heavily medullated types of fibers are objectionable because of their adverse effect on the spinning and dyeing properties of the wool, its tensile strength, and utility values. These types of fibers are most numerous in the birth coat of the lambs, but a high percentage of the fibers are shed during the early months of growth. Dry (1933, 1944) studied the hairy fibers of the Romney sheep. He found that the halo hairs together with many fibers of associated types, also referred to as birthcoat kemp, were nearly all shed during the first two or three months and often were replaced by secondary kemp fibers and very coarse hairy fibers of persistent growth. Grandstaff and Blunn (1944) reported that the average amount of kemp in the fleeces of Navajo lambs decreased from 15 percent at 28 days of age to 4.5 percent at 84 days, then maintained a fairly constant level until the lambs reached yearling age. Pohle *et al.* (1945) observed a rapid decrease in percentage medullation of hairy-fleeced lambs

[1] This study was conducted under authority of the Bankhead-Jones Act, by the Bureau of Animal Industry, U. S. Department of Agriculture, in cooperation with the Office of Indian Affairs, U. S. Department of the Interior, at the Southwestern Range and Sheep Breeding Laboratory, Ft. Wingate, N. Mex.

[2] United States Department of the Interior and collaborating with the United States Department of Agriculture.

[3] With the United States Department of Agriculture when the work was carried on; resigned August 24, 1946

of the Rambouillet, Targhee, Corriedale and Columbia breeds, between two and five months of age. The purpose of this paper is to present the results of a comprehensive study of kemp and other medullated fibers in the fleeces

TABLE 1. AVERAGE PERCENTAGES OF KEMP AND OTHER MEDULLATED FIBERS IN LAMB FLEECES AT 13 DIFFERENT AGES

Year born	No. of lambs	Percentages at indicated ages in days												
		28	56	84	112	140	168	196	224	252	280	308	336	364
Kemp from Navajo Lambs														
1940	49	5.5	2.1	0.8	0.6	1.0	1.0	1.2	0.9	1.3	1.4	1.4	1.1	1.1
1941	10	10.9	5.4	3.0	2.1	3.8	2.3	2.6	2.0	2.0	2.1	2.6	2.1	1.5
1943	63	8.1	7.2	2.6	1.5	[illegible]2.3	2.0	2.0	1.5	1.3	1.2	0.6	0.5	0.7
1944	22	4.1	2.0	1.4	0.9	1.3	1.2	2.0	1.6	1.3	0.6	0.7	0.8	0.5
Total or average	144	6.8	4.6	1.8	1.1	1.8	1.5	1.5	1.3	1.3	1.2	1.0	0.9	0.9
Other Medullated Fibers from Navajo Lambs														
1940	49	33.0	21.0	15.2	17.0	16.4	16.0	16.5	15.6	13.2	14.2	13.4	13.8	14.4
1941	10	16.7	5.4	7.0	9.8	6.8	8.2	7.2	4.8	4.1	3.4	4.0	4.1	4.1
1943	63	33.2	25.1	15.4	12.3	10.0	10.3	7.4	7.6	7.4	7.1	6.2	5.4	6.4
1944	22	16.1	12.0	9.7	6.9	7.2	5.6	5.3	4.2	5.2	2.3	2.7	3.3	2.5
Total or average	144	29.1	20.3	13.9	12.9	11.5	11.5	10.2	9.6	8.8	8.5	8.0	7.8	8.4
Kemp from Crossbred Lambs														
1940	26	7.3	3.8	1.8	1.1	1.5	1.7	1.6	1.2	1.5	1.7	1.6	1.4	0.9
1941	90	6.6	1.8	1.3	0.8	0.9	0.6	0.6	0.5	0.5	0.6	0.5	0.6	0.8
1943	56	6.9	4.4	2.3	1.0	0.8	1.2	0.9	0.6	0.8	0.9	0.3	0.3	0.3
1944	65	6.5	4.5	1.7	1.3	1.6	1.2	1.0	0.8	0.5	0.3	0.2	0.3	0.5
Total or average	237	6.7	3.4	1.7	1.0	1.1	1.0	0.9	0.7	0.7	0.7	0.5	1.0	0.6
Other Medullated Fibers from Crossbred Lambs														
1940	26	44.9	22.8	15.2	16.6	15.5	13.6	14.6	12.4	11.5	12.3	13.2	13.1	14.7
1941	90	34.6	8.8	6.7	7.3	6.3	5.5	4.3	3.5	3.3	3.9	4.1	4.2	4.2
1943	56	28.0	16.3	11.1	8.1	5.1	4.8	2.7	2.6	2.8	3.3	3.7	3.6	3.6
1944	65	17.9	12.8	9.2	6.0	5.9	3.8	2.6	1.9	2.0	1.6	2.4	2.6	2.1
Total or average	237	29.6	13.2	9.4	8.2	6.9	5.8	4.6	3.8	3.7	4.5	4.5	4.6	4.7

of Navajo and crossbred lambs as a basis for determining the optimum age for selection of lambs to effect maximum improvement in fleece quality.

Materials and Methods

Data for this study were obtained on 144 Navajo and 237 crossbred lambs born in 1940, 1941, 1943, and 1944. The fleece of each lamb was evaluated

for percentages of kemp and other medullated fibers at 13 different ages ranging from 28 days to 364 days, by means of small samples collected from the middle of the left side and thigh (Grandstaff and Blunn, 1945). For the first sample the fibers were cleared from an area about 1.5 inches square. Subsequent samples representing about 28 days' growth were taken from adjoining areas, except that in 1944 the same area was sampled each time.

The percentages of kemp and other medullated fibers in each sample were determined by a rapid microscopic method developed at the Southwestern

TABLE 2. DIFFERENCES IN PERCENTAGES OF KEMP AND OTHER MEDULLATED FIBERS IN LAMB FLEECES SAMPLED AT 28-DAY INTERVALS

Age in days	Navajo		Crossbred	
	Kemp fibers	Other medullated fibers	Kemp fibers	Other medullated fibers
28- 56	−2.2**	−8.8**	−3.3**	−16.4**
56- 84	−2.8**	−6.4**	−1.7**	− 3.8**
84-112	−0.7*	−1.0*	−0.7**	− 1.2**
112-140	+0.7*	−1.4**	+0.1	− 1.3**
140-168	−0.3	0	−0.1	− 1.1*
168-196	0	−1.3**	−0.1	− 1.2**
196-224	−0.2	−0.6	−0.2	− 0.8*
224-252	0	−0.8*	0	− 0.1
252-280	−0.1	−0.3	0	+ 0.8*
280-308	−0.2	−0.5	−0.2	0
308-336	+0.1	−0.2	+0.5*	+ 0.1
336-364	0	+0.6	−0.4*	+ 0.1

* Significant.
** Highly significant.

Range and Sheep Breeding Laboratory. The fiber samples were cross-sectioned by means of the Hardy (1933) device, and projected on a ground glass field 7 × 11 inches in size. From the magnified image of the fiber cross-sections, 100 fibers were counted out as a representative portion and classified by type, i.e., non-medullated fibers and kemp and other medullated fibers. The fibers were recorded on a tabulator in their respective classes to facilitate rapid and accurate counting. The kemp fibers were distinguished from other medullated fibers by their large medullae, size, and cross-sectional contour. Kemp fibers are usually coarser than other fibers, and typically ribbon- or bean-shaped, but some are round or oval in shape. The statistical procedures used in analyzing the data are discussed in connection with the experimental results.

Data and Discussion

The changes in percentages of kemp and other medullated fibers in the fleeces of the experimental lambs from 28 to 364 days are shown graphically in figures 1 and 2. These curves are based on mean values for all Navajo and crossbred lambs sampled during a period of four years. The changes in fiber

TABLE 3. ANALYSIS OF VARIANCE FOR KEMP AND OTHER MEDULLATED FIBERS IN LAMB FLEECES

Source of variance	Navajo			Crossbred		
	Degrees of freedom	Mean squares for kemp	Mean squares for other medullated fibers	Degrees of freedom	Mean squares for kemp	Mean squares for other medullated fibers
Years	3	336.23**	9415.63**	3	71.83**	11,066.40**
Lambs within years	140	54.54**	297.32**	233	45.10**	221.50**
Ages	12	454.98**	5328.72**	12	732.77**	11,807.63**
Years×ages	36	24.33**	278.26**	36	7.21**	383.54**
Remainder (error)	1680	3.74	16.18	2796	3.99	22.39
Total	1871			3080		

** Highly significant.

content of the fleeces of lambs sampled within years followed similar trends but with somewhat greater variation between the various ages than is shown by the 4-year average. These data are summarized in table 1.

The 28-day samples from Navajo lambs contained an average of 6.8 percent of kemp and 29.1 percent of other medullated fibers, while at 364 days the percentages were only 0.9 and 8.4, respectively. Thus the average change in the fleeces of Navajo lambs from 28 to 364 days represents a reduction of 5.9 percent of kemp and 20.7 percent of other medullated fibers.

The crossbred lambs did not differ significantly from the Navajo lambs in percentages of kemp and other medullated fibers at 28 days of age, and followed the same general trend in fiber development except that the decrease in medullated fibers was more rapid up to 84 days of age, and continued at a slightly higher rate until the lambs had reached an age of about eight months. Between the ages of 28 and 364 days, there was an average decrease of 6.1 percent of kemp and 24.9 percent of other medullated fibers, both values being slightly higher than those observed for Navajo lambs. A little more than 80 percent of the decrease in kemp for both Navajo and crossbred lambs occurred between 28 and 84 days of age, with a loss in other medullated fibers of 73 percent for the Navajo and 81 percent for the crossbred lambs.

This marked change in fiber content of the lamb fleeces was associated with the shedding and loss of coarse birthcoat fibers.

Further loss of kemp occurred between the ages of 84 and 112 days, but at a retarded rate compared to that of the preceding periods. In the 28-day interval from 112 to 140 days, there was a definite increase in the average percentage of kemp for Navajo lambs, followed by a slight downward trend until the final sampling at 364 days of age.

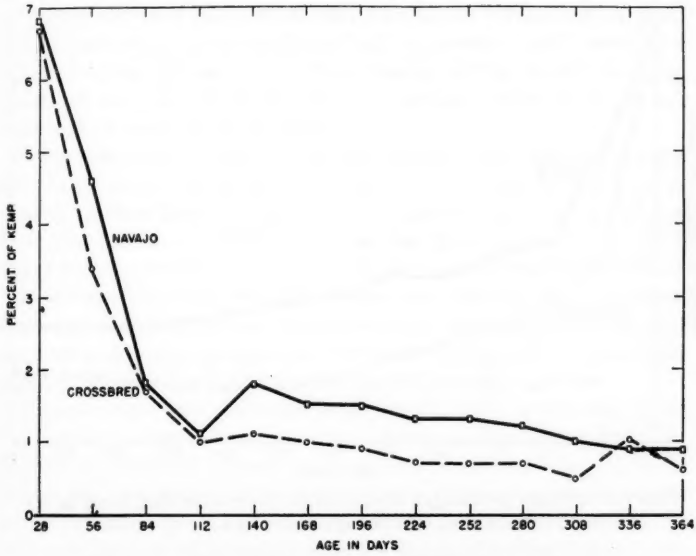

Figure 1. Average percentages of kemp fibers in lamb fleeces at 13 different ages covering a 4-year period.

Kemp increased slightly in the fleeces of crossbred lambs between the ages of 112 and 140 days, then maintained a slight downward trend to 308 days of age, followed by a rather sharp increase, and then in the final period decreased to about the same level that existed at 308 days. The fluctuations in percentages of kemp from 112 to 364 days probably resulted from periodic shedding of the fibers, followed by new growth from the same follicles. This is a natural characteristic of true kemp whereas the coarse medullated birthcoat fibers are not replaced by a similar type of fiber after being shed.

Following the rapid decrease in other medullated fibers from 28 to 84 days, there was a gradual decrease until early spring, then a slight increase as new growth of range plants provided a higher plane of nutrition.

The significance of the differences between the means of consecutive ages as determined by the t test, described by Fisher (1941), is shown in table 2.

The decreases in average percentages of kemp and other medullated fibers in the lamb fleeces during each of the 28-day periods, up to an age of 112 days, were significant or highly significant. After 112 days the mean differences for kemp were not significant, except in three instances, none of which affected the general trend. The decrease in medullated fibers was

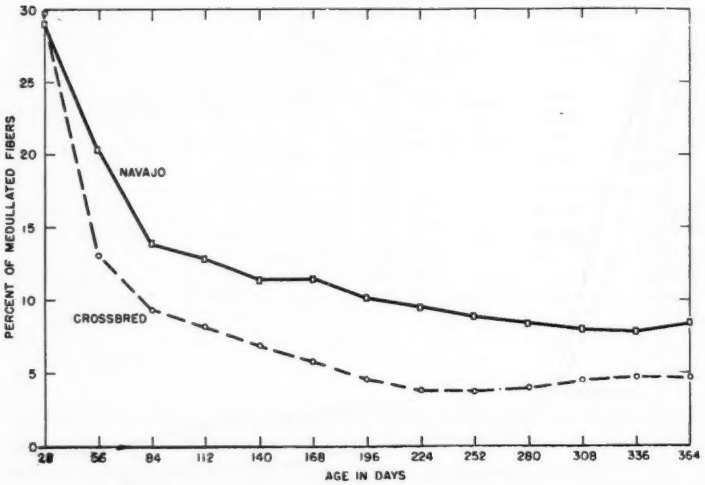

Figure 2. Average percentages of medullated fibers other than kemp in the fleeces of lambs at 13 different ages covering a 4-year period.

significant or highly significant at 56, 84, 112, and 140 days for both Navajo and crossbred lambs; also at 196 and 252 days for Navajo lambs, and at 168, 196, 224, and 280 days for crossbred lambs. Changes in the percentages of kemp and other medullated fibers at the 12 different ages, for Navajo and crossbred lambs, were highly correlated. Only the means at 28 and 56 days differed significantly from the means of all other periods.

In order to determine the magnitude and significance of the principal sources of variation, the data were studied by analysis of variance (Snedecor, 1940). Results of this analysis are summarized in table 3. The variance due to differences between years, lambs within years, ages, and also the interaction of years × ages were all highly significant for both Navajo and crossbred lambs. The greatest source of variance was that resulting from the changes in fiber content of the fleeces at different ages. The mean squares for cross-

bred lambs were about twice the size of the mean squares for Navajo lambs, but this was not surprising, for greater variation in the crossbred lambs was to be expected.

The next largest source of variance resulted from differences between the means of the four years. From 1940 to 1944 there was a significant decrease in the average levels of kemp and other medullated fibers for both Navajo and crossbred lambs, as a result of selective breeding. In 1940 the Navajo lambs at 364 days of age had an average of 1.1 percent of kemp and 14.4 percent of other medullated fibers, whereas the Navajo lambs studied in 1944 had only 0.5 percent of kemp and 2.5 percent of other medullated fibers at yearling age (see table 1). Some increase in fleece fineness was associated with the reduction of kemp and other medullated fibers, but finer wool was not an objective of the breeding.

Improvement in the fleeces of crossbred lambs studied was of about the same magnitude as shown for Navajo lambs. The average level of kemp at yearling age was lowered from 0.9 to 0.5 percent, and other medullated fibers from 14.7 to 2.1 percent during the four years represented. A major part of the improvement with respect to other medullated fibers occurred in 1941, when the averages for both Navajo and crossbred lambs decreased from more than 14 percent to about 4 percent. The decrease in 1944 compared with 1943 averaged only 3.9 percent for Navajo and 1.5 percent for crossbred lambs, but both figures were found to be highly significant.

Differences between individual lambs were greatest at 28 days of age and decreased rapidly during the early months of fiber development. At 28 days the fleeces of all lambs contained medullated fibers and about 90 percent had some kemp. At the age of 364 days, 58 percent of the crossbreds and 42 percent of the Navajo lambs were free of kemp as determined by the analysis of side and thigh samples. Also about 4 percent of the Navajo lambs and 14 percent of the crossbred lambs had no medullated fibers.

The analysis of variance shows that differences between lambs, after elimination of the effect of age and years, were highly significant. This fact clearly indicates that the average level of kemp and other medullated fibers in the fleeces of the experimental sheep can be reduced still further through selection.

Considering the most desirable age for sampling and evaluating the fleeces of lambs as a basis for selecting future replacements for the breeding flock, it might seem logical to choose an age when the differences between lambs are at a maximum. However, results of this study have shown that the period up to 84 days is unfavorable because of the rapid change in fiber characteristics of the fleeces. Medullated fibers decreased at an average rate of from 0.3 to 0.4 percent per day. Thus a differential of only 10 days in age

of the lambs might cause differences of 4 percent or more. Since the lambs normally have a spread in age of at least 28 days, it is obvious that selections should not be made until kemp and other medullated fibers have reached a fairly constant level, or about 112 days of age.

Summary

The fleeces of 144 Navajo and 237 crossbred lambs born in 1940, 1941, 1943, and 1944 at the Southwestern Range and Sheep Breeding Laboratory, Ft. Wingate, N. Mex., were sampled at 28-day intervals from birth to one year of age. Samples of 100 fibers taken from the middle of the left side and thigh of each lamb were analyzed microscopically for kemp and other medullated fibers.

From 28 to 364 days of age there was a reduction of 5.9 percent of kemp and 20.7 percent of other medullated fibers in the fleeces of Navajo lambs. For the crossbred lambs the decrease in both types of fibers was slightly greater than that observed for Navajo lambs. A major part of the change occurred between the ages of 28 and 84 days.

Differences between ages, years, lambs within years, and also the interaction of years × ages were highly significant for both breeds. The differences between years were associated with a significant improvement in fleece quality of lambs produced between 1940 and 1944.

Results of this study indicate that lambs which will have the most improved fleeces at yearling age can be selected with reasonable accuracy at about 112 days of age, when the fiber content of the fleece has reached a fairly constant level.

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PLACENTAL AND MAMMARY TRANSFER OF VITAMIN A IN SWINE AND GOATS AS AFFECTED BY THE PREPARTUM DIET

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LITTLE attention has been directed to finding the possible effect of the diet of farm animals upon the developing fetus or the well-being of the young. Studies with several species (Dann, 1932, 1934; Guilbert and Hart, 1934; Hart and Guilbert, 1941; McCay, 1941; and Lund, 1945) have led investigators to conclude that young mammals are deficient in vitamin A at birth and that the diet of the pregnant female has very little effect on the amount stored in the fetus. However, other reports, Wise *et al.* (1946), Spielman *et al.* (1946) and Baumann *et al.* (1934), indicated that the amount of vitamin A stored in livers of fetal calves and rats could be increased by giving massive doses of vitamin A to the pregnant female. Foot *et al.* (1938), Barron (1942), and Benham (1943) found appreciable quantities of vitamin A in the livers of new-born pigs.

Schofield (1941) and Benham (1943) noted that by giving sows large doses of vitamin A in late pregnancy the concentration of this vitamin in the colostrum of the sows was increased. The amount of vitamin A was found to be greater in sows' first colostrum than in later milk.

The amount of vitamin A in livers of newborn kids and the concentration of vitamin A in the colostrum of does appears not to have been studied.

Experimental

The extent of placental and mammary transfer of vitamin A to kids and pigs was investigated during the spring of 1946 using the young from 15 sows and 8 does. Four does were fed a standard ration of hay and grain and four pair mates were given, in addition to this ration, 100,000 I.U. of vitamin A each day beginning 42 days before they were due to kid. Six sows received 406,000 I. U. vitamin A per sow each day for an average of 32 days before farrowing. One sow received 406,000 I.U. of carotene for 28 days before farrowing, and eight sows were fed only the regular herd ration. Supplements, fed only until parturition, were given in addition to normal winter herd rations which were adequate for reproduction.

Newborn kids and pigs were killed before they sucked and samples of blood and liver were obtained for carotene and vitamin A analyses. Livers

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of pigs that died or were killed by the sow before sucking and stillborn pigs were also used for analyses.

A sample of colostrum obtained from one teat of each sow during parturition and composite samples of the total colostrum produced by the does during the first and second 24 hours after parturition were analyzed for carotene and vitamin A.

Carotene and vitamin A in blood plasma were determined by the method of Kimble (1939), in colostrum by the procedure of Boyer *et al.* (1944), and in livers by a procedure modified after Davies (1933).

TABLE 1. PLASMA VITAMIN A LEVELS OF NEWBORN KIDS AND PIGS

Prepartum ration	Pigs		Kids	
	No. of animals	Plasma Vit. A micrograms/100 ml.	No. of animals	Plasma Vit. A micrograms/100 ml.
Normal herd	4	6.4 (3.9–10.0)*	4	2.0 (0–6.0)
Normal herd+vitamin A	4	9.1 (6.8–10.5)	5	10.0 (8.0–12.0)
Normal herd+carotene	4	6.5 (5.4–8.9)	—	—

* Figures in parentheses are the lowest and the highest values observed.

Results

At the beginning of the experiment the average plasma vitamin A of the does was 35 micrograms per 100 ml. After receiving vitamin A supplement for one month the plasma level of the vitamin A group increased to 57 micrograms. At this time the unsupplemented does averaged 33 micrograms of vitamin A per 100 ml. of plasma. Determinations were not made of the carotenoids and vitamin A in the plasma of the sows.

Traces of carotenoids were found in only 2 of 13 samples of plasma from newborn kids, and in 10 of 16 samples of plasma from newborn pigs. The average plasma level of vitamin A of newborn kids from the does fed the normal ration was 2.0 micrograms per 100 ml. (table 1) and this was increased to 10.0 micrograms in the vitamin A supplemented group. In newborn pigs from sows on herd ration the plasma vitamin A level averaged 6.4 micrograms per 100 ml., and for the vitamin A supplemented group it averaged 9.1 micrograms. Newborn pigs from the carotene supplemented sow had plasma carotene and vitamin A values similar to those of the normal group (table 1).

Traces of carotenoids were found in the livers of all newborn kids and pigs, as judged by galvanometer deflections. The hepatic stores of vitamin A (table 2) were very low, only .06 micrograms per gram, in newborn kids from

does fed the herd ration, while the average concentration in the livers of newborn kids from vitamin A supplemented does was 9.9 micrograms per gram of fresh liver tissue, a 165-fold increase. The average total store of vitamin A was increased by a similar figure.

The average value for newborn pigs from sows fed herd ration (table 2) was 4.73 micrograms of vitamin A per gram of fresh liver tissue. For the vitamin A supplemented sows the corresponding figure was 35.8. The total

TABLE 2. STORES OF CAROTENOIDS AND VITAMIN A IN THE LIVERS OF NEWBORN KIDS AND PIGS

Prepartum ration	No. of females	No. of livers	Carotenoids, micrograms/gram	Vitamin A, micrograms/gram	Total, I.U.*
Newborn kids					
Normal herd	4	6	0.25 (.07–.37)**	0.06 (.01– .15)	36 (4– 70)
Normal herd+vitamin A	4	8	0.23 (.08–.40)	9.91 (1.94–16.56)	2702 (810–4993)
Newborn pigs					
Normal herd	6	11	0.17 (.09–.76)	4.73 (.85–11.67)	354 (78– 902)
Normal herd+vitamin A	4	9	0.24 (.14–.44)	35.8 (25.5 –46.9)	4615 (1591–8274)
Normal herd+carotene	1	5	0.25 (.08–.35)	8.0 (1.46–14.52)	593 (141–1215)

* Total I.U. = (micrograms of vitamin A×4.0)+(micrograms of carotenoids×1.66).
** Figures in parentheses are the lowest and highest values observed.

liver stores of vitamin A in each fetus were increased by a factor of 13 as a result of supplementing the pregnant sow with vitamin A. All offspring examined from vitamin A supplemented females contained more vitamin A than did offspring from unsupplemented females. The amount of vitamin A in the livers of newborn pigs from the carotene supplemented sow was within the range of values observed for the normal group. The hepatic stores of vitamin A found in stillborn pigs was within the range found for pigs born alive and then killed.

The fat percentage of the first day's colostrum of the goats averaged 8.2 percent as determined by the Babcock test. The average for the second day's colostrum was 7.4 percent. The first colostrum of 11 sows averaged 4.9 percent fat. Traces of carotenoids were found in most samples of colostrum produced by the does and the sows.

The concentration of vitamin A in the first day's colostrum produced by does in the vitamin A group (table 3) averaged three times the value of the normal group. The second day's colostrum averaged more than twice that found in the colostrum of the normal group of does. The amount of vitamin A per gram of fat was calculated by assuming a specific gravity of 1.032 for the

colostrum. These figures showed a marked increase for the vitamin A group. The total output of vitamin A in the does colostrum was increased 2.5 to 3.0 times by supplementing the prepartum diet of the does with vitamin A.

TABLE 3. VITAMIN CONTENT OF COLOSTRUM PRODUCED BY DOES AND SOWS

Prepartum ration	No. of animals	Vitamin A		
		Micrograms/100 ml.	Micrograms/gram fat	Total I.U.*
Dairy goats—first day composite				
Normal herd	4	433 (232- 772)**	51 (36- 69)	33,397 (1294- 35,422)
Normal herd+vitamin A	4	1353 (1004-1785)	135 (104-166)	97,941 (69,994-113,895)
Dairy goats—second day composite				
Normal herd	4	137 (108-170)	18 (13- 24)	10,041 (833- 14,137)
Normal herd+vitamin A	4	361 (236- 585)	51 (44- 64)	20,718 (18,941- 25,622)
Sows—first colostrum				
Normal herd	8	169 (87- 222)	32 (18- 45)	
Normal herd+vitamin A	6	519 (154-1050)	75 (45-120)	
Normal herd+carotene	1	124	33	

* Total I.U. = (micrograms of vitamin A×4.0)+(micrograms of carotenoids×1.66).

** Figures in parentheses are the lowest and highest values observed.

The vitamin A concentration of the first colostrum produced by eight sows on normal ration (table 3) averaged 169 micrograms per 100 ml. The corresponding average for six sows supplemented with vitamin A before farrowing was 519 micrograms. The concentrations per gram of fat were calculated on samples which were of sufficient volume to determine fat percentage. The carotenoid and vitamin A concentrations in the colostrum of the carotene supplemented sow were similar to those for normal sows. With one exception all vitamin A supplemented females produced colostrum with greater concentration of vitamin A than were found in colostrum from females whose diet was not reinforced with vitamin A.

Summary

Data are reported which show that the extent of placental and mammary transfer of vitamin A in goats and swine can be increased by the addition of large amounts of vitamin A to the diet of the pregnant female. Under normal feeding conditions where the diet of the pregnant females contained usual amounts of carotenoids, but no vitamin A, newborn kids were found to

have negligible quantities of vitamin A in their livers, but newborn pigs had appreciable hepatic stores. The addition of massive doses of vitamin A to the diet of the doe or sow during the last quarter of gestation caused a large increase in the amount of vitamin A in the plasma and liver of the young.

Colostrum produced by dairy goats had larger concentrations of vitamin A than colostrum produced by sows when the pregnant females received the usual winter rations. Feeding massive doses of vitamin A during late pregnancy markedly increased the vitamin A content in the colostrum produced by both does and sows.

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ARTIFICIAL REARING OF BABY PIGS[1]

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THE raising of baby pigs under artificial conditions should have many advantages. From an experimental standpoint, it would permit detailed studies of the physiology and nutritional requirements of pre-weanling pigs. It would also afford a method to study diseases of little pigs. A more accurate estimate of genetic influences on the pig's ability to grow might be possible as maternal influences which are so great during the sucking period and which affect the growth of the pig for a period past weaning (Nordskog *et al.* 1944) could be removed. In a practical way, pigs can be raised free of parasites; larger and more vigorous pigs probably could be produced at the end of 8 weeks of age; more litters could be obtained from each sow per year; maintenance costs of the breeding herd would be reduced because the sows would not have to be conditioned for the nursing period; and the pigs so produced would probably make more rapid and economical post-weaning gains because they could be larger and physiologically more mature at weaning age. A modification of the equipment to be described would also afford farmers a more practical method of raising orphan pigs than the present recommended ways (Smith, 1937).

The objectives of this present study were to study some of the habits of baby pigs and to design practical equipment for handling the pigs.

Observations on the Habits of Baby Pigs

The first experiments were conducted on the feeding habits of baby pigs. Difficulty in teaching pigs to use nippled bottles provoked the use of shallow dishes for feeding milk. Pigs ranging from those which had never nursed to those one week old were taught to drink by submerging their mouths in luke warm cow's milk after they had become hungry. Luke warm milk was used to prevent any temperature shock to the little pigs. For the first lesson or after the first lesson, the milk may be at room temperature. Beginning the second day the milk may be fed at ordinary refrigerator temperatures if so desired. The pigs seem to relish the cool milk and no digestive troubles were encountered. If the pigs are in a large cage, those less than two days old have to be shown the location of the pan once or twice. Three-day pigs have the ability to locate the milk after one good feeding.

In the first feeding trials, week old pigs were taught to drink in the above

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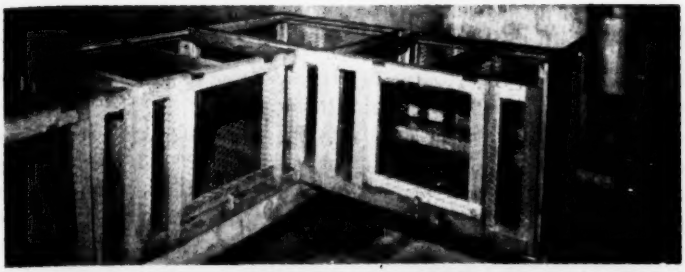
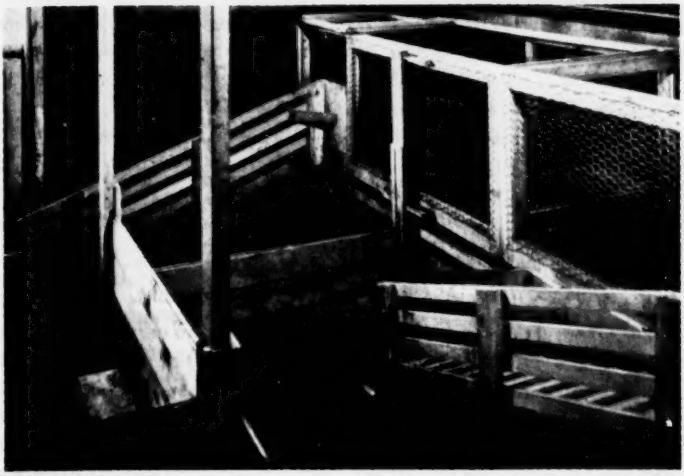




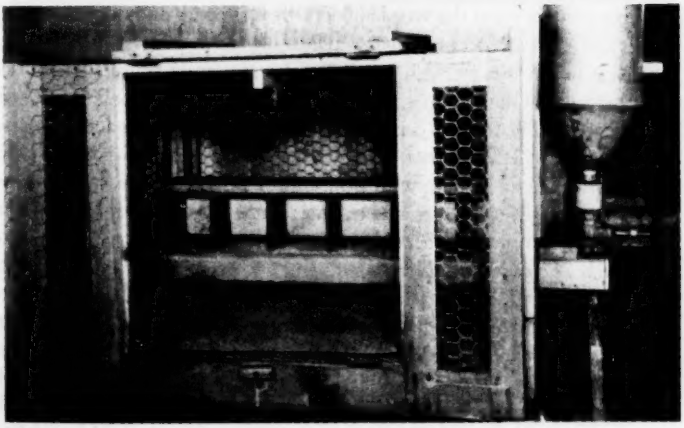


Figure 1 (Top). General view of one cage with feeding equipment in place.
Figure 2 (Middle). General view of a cage equipped with a ramp.
Figure 3 (Bottom). Illustration of feeding equipment in cage shown in figure 1.

manner. This was not necessary as later experience proved that 7-day pigs will locate the milk and learn to drink by themselves.

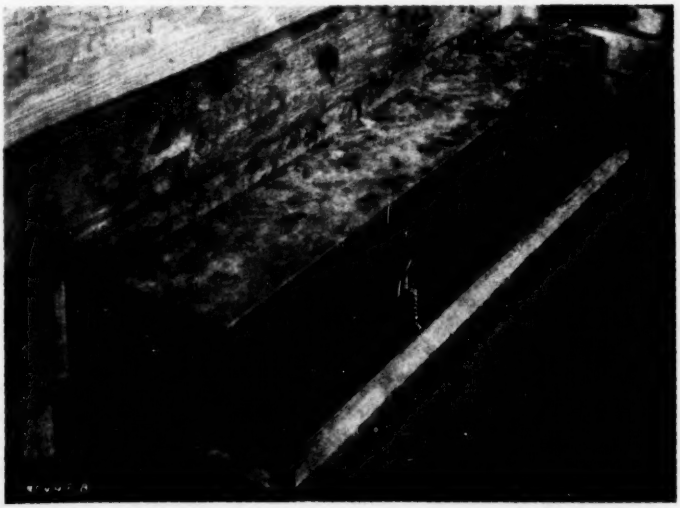
When milk was constantly available, the pigs would drink at intervals during the 24 hours. No digestive troubles assignable to this *ad lib.* feeding method were encountered. One group of pigs which had been removed from their dams and had not eaten for 36 hours did gorge themselves to a point where they immediately regurgitated their first drink of milk but within one hour they had settled down to consuming rational quantities of milk and no further trouble was encountered. If more than one pig were in a pen at one time, all pigs would try to drink at one time similar to their actions when with the sow. This instinct did not appear to leave until the pigs were 5–7 weeks old. The pigs soon lost their desire to suckle.

The young animals required their feed to be in a liquid form. Various gruels were used but after drinking the milk from the surface, they would leave the soft mushy residues. Like naturally raised pigs, these would start to eat some dry feed when about two weeks old but they ate very little dry feed when they had all of the milk they wanted.

Design of Cages and Other Equipment

The first cages used were 6 ft. long, 2 ft. high and 30 in. wide. They had wooden floors and a wooden superstructure frame which was covered with ½ in. galvanized iron hardware cloth. Milk was fed by using a stoppered, inverted Erlenmeyer flask with a rubber tube leading to a glass dish 4 in. in diameter and 2 in. deep. Shavings were unsatisfactory as bedding as the little pigs ate pieces and this caused gastro-intestinal trouble. As straw was also unsatisfactory and the wooden floors were slippery and difficult to keep sanitary, wire mesh floors were substituted.

A cage which was found to be practical is shown in figure 1. It is made of three identical units bolted together. Each unit is 41 in. long, 24 in. high by 36 in. wide. The frame is constructed of 1 in. × 2¼ in. pieces and is covered on the sides and ends with 1 in. hexagonal galvanized iron poultry mesh. The doors are 24 in. × 24 in. with 1 in. × 2½ in. rails and stiles, hinged at the top with 3 in. light tee hinges, and fastened at the bottom with wooden turn buttons. The doors are unnecessary. The removable ends are held in place by bolts, the holes for which are bored after a template so the ends and units could be interchanged. A permanent floor of ½ in. galvanized iron hardware cloth is stapled to the bottom rail which is made of 2 in. × 4 in. pieces on edge. Cross pieces of 1 in. × 2½ in. boards on edge were used for center cross braces top and bottom. Removable inset pieces of ¼ in. galvanized iron hardware cloth were placed over the permanent floor when the pigs were small. The cages are placed 18 in. above the floor by use of trestles and supporting members.



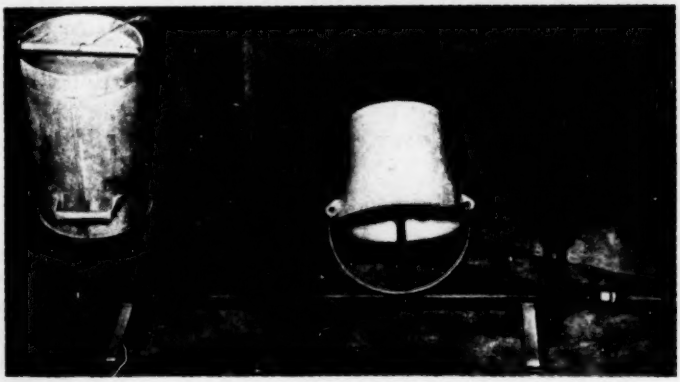


Figure 4 (Top). Detail of construction of feeding stall (trough in place).
Figure 5 (Middle). Metal trough and wooden protector (metal trough is placed inside protector and on top of cross pieces).
Figure 6 (Bottom). Rack suitable for sterilization.

A second set of cages were arranged as shown in figure 2. They are constructed in the same way as described above except that they are 78 in. long and are equipped with a ramp to permit the pigs to use the floor for exercise and feeding.

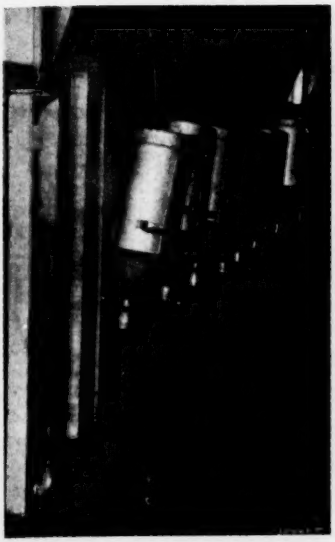
The equipment used for feeding is shown in figure 1, 3, 4, 5, and 8. The stalls were made by using 1 in. $\times$6 in. backs and tops with 1 in. $\times$6 in. $\times 4\frac{3}{4}$ in. pieces spaced about 6 in. apart (figures 3 and 4.) The superstructure was nailed in a permanent position in such a way as to allow about 1 in. clearance between it and the top of the removable trough. The latter was made of galvanized iron and was 46 in. long, 2 in. high and 5 in. wide at the top and 4 in. wide at the bottom with the sides and ends beveled starting 1 in. from the top (figure 5). A removable wooden frame was used to protect the trough (figures 3, 4, and 5).

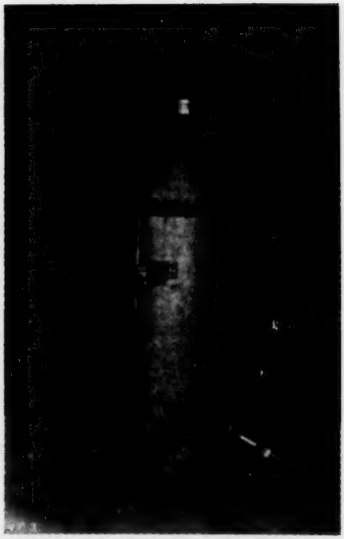
Reserve milk was contained in 20 gauge galvanized iron cans $10\frac{3}{8}$ in. in diameter, 15 in. high from the bottom to the shoulder (approximate 5 gallon capacity). A 2 in. extension was placed around the bottom of the can and a handle fixed in this area to facilitate handling of the can (figures 6 and 8). The conical top was tapered to contain a 2 in. pipe, threaded on the exposed end, at the top (figure 8). A 2 in. pipe coupling with a 2 in. by 1 in. bushing and a 1 in. close nipple were used to connect the can to a 1 in. gate valve. Distally, a short 1 in. nipple with a protector to keep the nipple 1 in. above the bottom of the trough led the milk from the valve to the trough. After filling, the can, with the valve closed, was inverted over the trough and supported by a wire (figures 1, 3, 6 and 8). To prevent air leakage around the coupling, that part was lubricated with vaseline. The cans may be tapered so the opening will accommodate a number 12 stopper, which is removed after the can is in place, thus not requiring the valve arrangement. Use of a valve is more satisfactory.

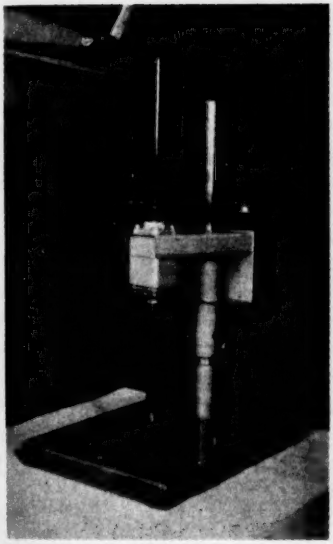
As long as milk remained in the reserve can, the milk in the trough remained about 1 in. deep. Air, going into the can when the pigs drank, agitated the contents of the can sufficiently to prevent any undue separation of the milk.

Experience in Using the Equipment

The troughs, wooden guards, valves and other small items were sterilized by placing them in a galvanized iron trough $4\frac{1}{2}$ ft. long, 12 in. deep and 9 in. wide. The equipment was inundated with cold water, tri-sodium phosphate added, and the water heated to boiling by means of live steam. The cans, pails, mixing container, etc., were washed with cold, then hot water and were then sterilized by placing them on a rack (figure 6) and treating them with live steam. The rack was made of a $\frac{3}{4}$ in. pipe, welded to supports, with







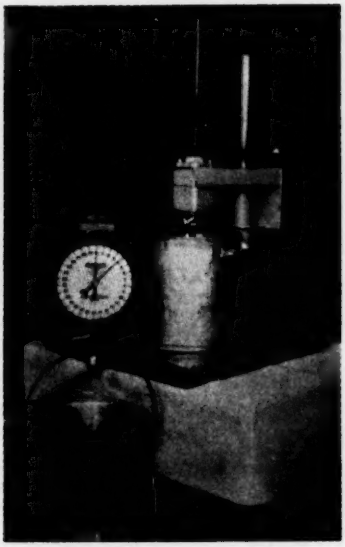


Figure 7 (Upper Left). Reserve rack of cleaned feeding equipment.
Figure 8 (Upper Right). Reserve can for milk with fittings.
Figure 9 (Lower Left). Stirrer used for reconstituting dried skim milk.
Figure 10 (Lower Right). Stirrer in place in mixing container.

½ in. vertical pipes welded to it. Caps were placed over unused uprights. Steam was led to the rack from a high pressure line by means of a rubber steam hose fitted to a union. Prior to placing the cans on the rack, a 2 in. pipe coupling was screwed onto the top of the can to protect the threads (figures 6 and 8). After sterilization, the cans and other equipment were hung from racks (figure 7).

Cages were cleaned by using cold and hot water under pressure. The wire bottoms allowed all urine and most of the feces to fall to the floor when deposited. The floor was flushed into a central drain.

When 3.5 percent butterfat pasteurized cow's milk was fed, the milk was poured directly from the bottles into the cans. As mentioned previously, the air going into the reserve can periodically stirred the contents and no trouble was encountered with the butterfat "creaming out." Dry skimmilk was reconstituted by use of an electrically driven stirrer (figures 9 and 10). The motor and stirrer shaft were adjustable on the upright standard which permitted easy handling of the unit. The base of a ten-gallon milk can appropriately fitted with an outlet made a convenient container, the contents of which could be weighed directly into a suspended pail. Water for the milk was handled in a similar manner.

Fresh milk was given the pigs each morning. Although the barn was heated to normal room temperatures at all times in cold weather and fully exposed to summer temperatures, no difficulty was encountered with the milk souring or putrifying. Although one of the ultimate objectives of this work is to devise a ration which will be satisfactory for raising the baby pigs from birth to the usual weaning age (8 weeks) that portion of the study has not progressed to a practical solution; therefore, the rations used and their effects will not be presented at this time.

The equipment described above has been found satisfactory, convenient, and practical for the raising of baby pigs. The pigs apparently do not suffer in any way from discomfort when raised on wire. Knees and hocks do not become sore or scraped, and knee sores which are found when the pigs arrive at the laboratory (to date most of the pigs used have been with their dams for 7 days) heal quickly with no special treatment. Foot sores have not developed and the pasterns have not been weakened. The apparent lack of exercise space for those pigs kept in cages such as the one shown in figure 1 did not affect the vigor or general health of the young animals.

As a routine procedure, week-old pigs were given sacks to use as a bed for the first two days they were in the cage. The sacks were then removed. For some of the day-old pigs which were kept in other but similar cages, a sack bed was placed under an electric-light incubator for a few days. As the

pigs grew older, they depended less on the heat from the lamp so that the latter could be dispensed with by the end of a week.

From a sanitary standpoint, it would be better to have the whole cage and feeding apparatus made of metal as the wood soaks up some waste materials and water at cleaning time. These cages have not, however, caused any trouble to date. At times when the pigs would scour from infections brought with them from the barn, the situation was always handled promptly and satisfactorily by the use of sulfa drugs put into the milk.

Some indication has been found to give support to the theory that pigs raised artificially may be able to attain relatively heavy weights at 8 weeks of age. Some of the feeding work included circumstances which allowed pigs to attain that age. Of ten Minnesota No. 1 pigs of different litters and one Minnesota No. 1 × Poland China crossbred pig raised to 8 weeks, eight weighed between 45 and 60 pounds and three weighed between 30 and 35 pounds. One of the latter group was an undersized pig from birth. Although naturally raised pigs have attained similar weights, they are not to be found in the same proportion of the population as were the pigs raised artificially.

Summary and Conclusions

A study of some of the habits of baby pigs suggests that it is possible and practical to teach small pigs to drink at an early age and that milk may be offered *ad libitum*.

Illustrations and construction specifications have been given for cages which are satisfactory for rearing baby pigs under artificial conditions. Apparently the pigs so raised are not handicapped by their environment. The advantages of rearing baby pigs under artificial conditions are pointed out and the use of the equipment is discussed.

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MORPHOLOGY OF SPERMATOZOA FROM DIFFERENT LEVELS OF THE REPRODUCTIVE TRACT OF THE BULL[1]

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IN THE course of investigations to establish the relationship between measurable characteristics of bull semen and its quantitative fertility in artificial insemination, att.ntion has been focused on the source of morphologically abnormal spermatozoa. Studies in this laboratory (Salisbury *et al.*, 1942, and Mercier, 1944, 1946) have shown that the method used in making, clearing, and staining semen smears may influence markedly the proportion of morphologically abnormal spermatozoa observed. Since the percentage of some types of abnormalities were relatively constant in the semen of any one particular bull, it was believed that the original source of these abnormal types of spermatozoa could be satisfactorily established by studies of the fluids and the spermatozoa at various levels of the male reproductive tract. Only two reports (Sciuchetti, 1938 and Lagerlöf, 1934) concerning the proportion of abnormal spermatozoa at different levels of the excurrent ducts of the bull were found in the literature.

Materials and Methods

The materials for these studies were obtained from the genitalia of 21 bulls slaughtered at a local abattoir. The bulls were either Holsteins or Guernseys with the exception of a few of mixed breeding. They were of various ages and all except 2 were free from disease. Of the 2 bulls, one was a Bang's reactor and the other had a tumor on his penis. In only 3 cases was the fertility of the bulls known.

In most instances the entire reproductive tract of each bull was removed within 15 minutes after slaughter. Fluids from epididymides and ampullae were collected as soon as possible thereafter. The testes were dissected free of the scrotum and tunica albugina. Then, through an incision made into the head of the epididymis, and by gently massaging this region, a drop or two of fluid was obtained upon a clean microscopic slide. The same technique was used to obtain fluid from the body of the epididymis.

The fluid from the tail of the epididymis was obtained by modifications of

[1] The data contained in this paper are from a thesis presented by the senior author to the Graduate School of Cornell University in partial fulfillment of the requirements for the degree of Master of Science in Agriculture, 1946.

[2] This author wishes to acknowledge his indebtedness to Professor C. B. Knodt, Department of Dairy Husbandry, Pennsylvania State College, State College, Pa. for help in planning and conducting these investigations.

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the methods described by Lasley and Bogart (1944) and Lardy *et al.* (1945). The method most often employed was that of dissecting the tail of the epididymis from the testis and leaving about 6 inches of the vas deferens attached. A physiological saline solution was injected into the vas deferens through a 24-gauge needle attached to a 10 cc. syringe. Injection of the saline was continued until the majority of the cauda epididymal fluid was forced into a small test tube. Removal of the test tube before the saline came through the epididymis was necessary to prevent contamination of the sample with saline.

TABLE 1. MEAN PERCENTAGES OF MORPHOLOGICALLY ABNORMAL SPERMATOZOA FROM SIX BULLS

Abnormalities of:	Epididymal samples		Ampullar samples
	Head	Tail	
Head	5.23	5.09	5.80
Neck	0.40	0.65	0.89
Mid-piece	1.42	2.09	1.69
Tail	2.24	2.83	1.93
Total	9.28±3.15[1]	10.66±1.22	10.32±2.79

[1] Standard error of a single observation.

The ampulla was isolated from its surrounding membranes and tissues, clamped off from the urethra, and severed from the remainder of the vas deferens. Then the fluid was collected by stripping the ampulla between the index finger and thumb.

The morphological studies of the spermatozoa from the head, body, and tail of the epididymides of 15 bulls were made by the methods described by Salisbury *et al.* (1942) and Mercier (1944). On the other hand, the technique recommended by Lasley and Bogart (1943) was used to study the morphology of the spermatozoa from the head and body of the epididymides and from the ampullae of 6 other bulls. This latter technique was also used for the purpose of studying the proportion of spermatozoa with attached protoplasmic droplets.

Results

Morphologically Abnormal Spermatozoa

The mean percentages for the totals of the morphologically abnormal spermatozoa, excluding tailless spermatozoa, from the head, body, and tail of the epididymides of the 15 bulls were 13.88, 14.16, and 14.95, respectively. The differences were not statistically significant. However, there was a highly significant statistical difference (significant at 1 percent level of

probability) between bulls. These bulls ranged from 9.8 to 19.5 percent in total morphologically abnormal spermatozoa, excluding tailless spermatozoa.

On the 6 other bulls spermatozoa from the ampullae were observed and the percentages of abnormals compared with the percentages observed in the samples from the head and tail of the epididymides. The comparisons are shown in table 1. Here again no statistically significant differences were obtained. Furthermore, in all cases the predominant types of abnormalities were those affecting the heads of the spermatozoa.

TABLE 2. AVERAGE PERCENTAGES OF SPERMATOZOA HAVING PROTOPLASMIC DROPLETS ON THEIR NECKS, MID-PIECES, OR TAILS FROM THE HEAD AND TAIL OF THE EPIDIDYMIDES AND AMPULLAE OF SIX BULLS

Location on spermatozoa	Level of tract		
	Epididymis		Ampulla
	Head	Tail	
Neck	60.11±13.98	5.88± 1.51	2.61±1.56
Mid-piece	16.67± 8.97	52.40±10.21	12.02±3.81
Tail	3.54± 2.29	4.62± 2.40	8.56±3.57
Totals	80.32± 6.29[1]	62.90± 2.40	23.19±6.13

[1] Standard error of a single observation.

Protoplasmic Droplets

Another morphological characteristic of spermatozoa which was observed before and after staining the smears in the studies above was the presence or absence of a protoplasmic droplet on the spermatozoa. As described by Lagerlöf (1934), Selivanova (1937), Donham and Simms (1931), and Fincher *et al.* (1942), it was observed to be a round mass of cytoplasm or protoplasm which usually surrounded the neck or some part of the mid-piece of the spermatozoa. Although these workers have noted that the proportion of spermatozoa bearing the droplet varies from one level of the reproductive tract of the bull to the other, no data on the relative percentages were published. The question of whether or not all bulls showed comparatively the same percentage of spermatozoa bearing the protoplasmic droplet at any particular level of their excurrent ducts was not satisfactorily answered. Therefore, this morphological characteristic was studied as shown in table 2. These studies were made on samples from the same 6 bulls for whom data in table 1 are shown.

In this group of 6 bulls the analysis of variance revealed highly significant differences between the means of the percentages of protoplasmic droplets

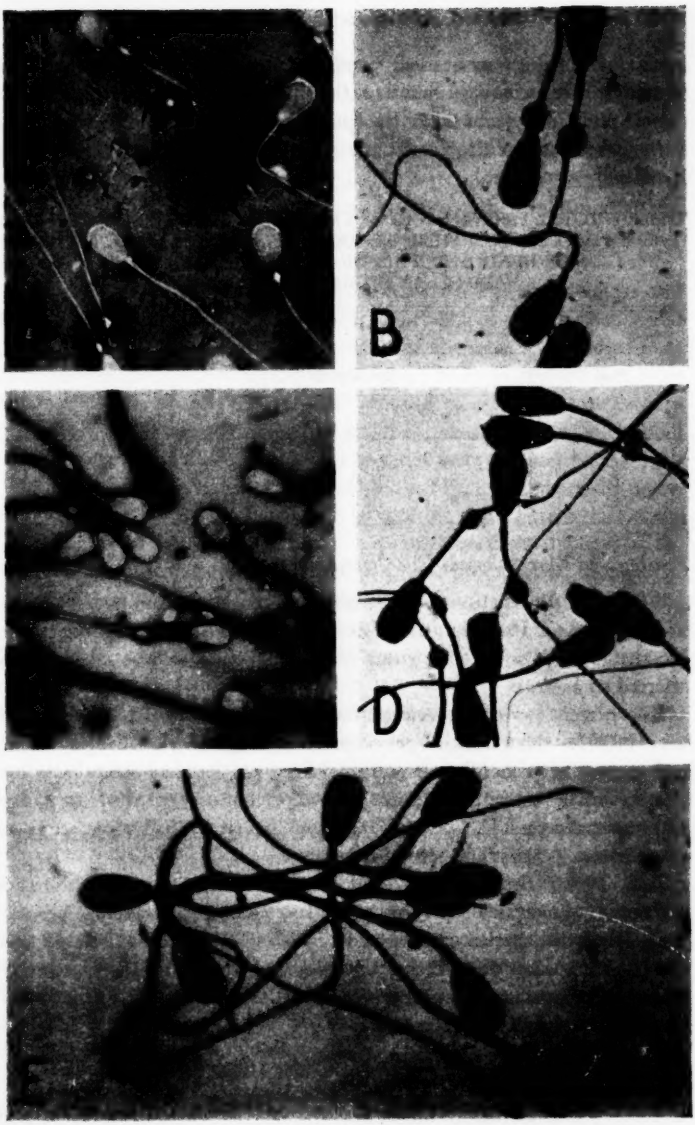

Figure 1. Spermatozoa from different levels of the reproductive tract of the bull, as follows: A—Head of the epididymis; B—Body of the epididymis; C and D—Tail of the epididymis; and E—Ampulla. Spermatozoa in A and C were stained with opal blue-eosin and in B, D, and E with aniline gentian violet and Ziehl's carbol fuchsin.

at all levels of the tract studied. Similarly, in the group of 15 bulls highly significant differences were found for the 3 higher levels of the tract studied: namely, head, body, and tail of the epididymides. Differences between bulls in the percentages of droplets at any particular level of the tract were not statistically significant.

TABLE 3. TOTAL PERCENTAGES OF THE SPERMATOZOA HAVING PROTOPLASMIC DROPLETS ON THEIR NECKS, MID-PIECES, AND TAILS, FROM THE THE HEAD AND TAIL OF THE EPIDIDYMIDES AND AMPULLAE OF BULLS A, B, AND C

Bull	Level of tract		
	Epididymis		Ampulla
	Head	Tail	
A	79.8	66.7	27.1
B	85.2	65.5	34.0
C	82.3	51.4	20.0

Fertility and Morphological Characteristics

Very little information could be obtained concerning the fertility of the 21 bulls studied. However, the New York Artificial Breeders' Cooperative Inc., had records on 3 of the group of 15 bulls which will be subsequently referred to as A, B, and C.

The percentages of non-returns for service were calculated for each of these bulls for the 6 months' period prior to slaughter. A, a Bang's reactor, had 56 percent (2 months' non-returns) from 549 first and second services. B, a bull with a tumor on his penis, had 77 percent non-returns from 49 first and second services. C, a bull who was low in fertility, had 46 percent non-returns from 457 first and second services.

Each level of the tract of bulls A, B, and C contained about the same percentage of morphologically abnormal spermatozoa. The average percentage of abnormal spermatozoa, excluding tailless spermatozoa, isolated from the excurrent ducts of A, B, and C was 8.01, 9.23, and 10.44, respectively. The total percentages of spermatozoa from the same bulls having attached protoplasmic droplets are shown in table 3.

Discussion

The results reported herein show that the levels of the excurrent ducts of the bull did not differ significantly in the percentages of morphologically abnormal spermatozoa, excluding tailless spermatozoa, when either the staining technique recommended by Salisbury (1942) and Mercier (1944) or

Lasley and Bogart (1943) was used. Since this was the case and since the predominant types of abnormals were those affecting the heads of the spermatozoa, it seems reasonable to conclude that the original source of morphologically abnormal spermatozoa is the testes. This agrees with the conclusion one might draw from the findings of Lagerlöf (1934). He presented quite convincing evidence that there are normally no recognizable changes in the morphology of spermatozoa during their passage through the reproductive tract of the bull.

The percentages of abnormal spermatozoa from the epididymides and ampullae reported by Sciuchetti (1938) are much higher than those reported in this paper. He found that the proportion of abnormal spermatozoa from the epididymides of the bull ranged from 13.07 to 45.33 percent, and from the ampullae the proportion ranged from 19.68 to 45.75 percent. Perhaps the use of different staining techniques and the study of different bulls would explain most of the differences reported by the authors and Sciuchetti (1938).

Three types of spermatozoa, differentiated as to the location of the protoplasmic droplet, were observed at each level of the reproductive tract of the bull (table 2 and figure 1, A to D). The spermatozoa from the head of the epididymides were mostly of the type with the protoplasmic droplets attached to their necks (figure 1, A and table 2). Those from the body of the epididymides had most of the droplets on their mid-pieces (figure 1, B). On the spermatozoa from the tail of the epididymides the droplets were generally attached to the posterior region of the mid-piece (figures 1, C and 1, D), whereas, most of the droplets were absent from the ampullar spermatozoa (figure 1, E). These changes in the location on the spermatozoa and the gradual disappearance of the droplets at the different levels of the reproductive tract further confirm the observations of previous workers (Lagerlöf, 1934; Selivanova, 1937; and Donham and Simms, 1931). As these workers seemed to agree, it is logical to assume that spermatozoa mature as they pass through the epididymis. The droplet finally becomes attached to the posterior region of the mid piece of the spermatozoa. Before the spermatozoa become a component of the normal ejaculate of the bull, the droplets are detached. Thus, the droplet is usually absent from the ejaculated spermatozoon. The results reported by the above workers and herein indicate that these changes are stages in the morphological development of spermatozoa and that all normal bulls exhibit these stages.

Summary and Conclusions

Studies were made on the morphological characteristics of spermatozoa from the reproductive tracts of 21 bulls of different ages. Fertility of only 3 of these bulls was known. Information on the source of morphologically ab-

normal spermatozoa and the relative proportions of morphologically abnormal spermatozoa, excluding tailless spermatozoa, and spermatozoa with attached protoplasmic droplets was secured.

It was found that the various levels of the reproductive tract of the bull did not differ significantly in the proportions of abnormal spermatozoa and that the predominant types of abnormals were those affecting the heads of the spermatozoa. It was, therefore, concluded that the testis is the original source of morphologically abnormal spermatozoa.

All bulls studied had three types of spermatozoa as to the location of the protoplasmic droplet. There was no significant statistical difference between bulls as to the proportion of spermatozoa with attached droplets at any given level of the tract. However, the droplet was usually located on the neck of spermatozoa from the head of the epididymis, and was usually absent from ampullar spermatozoa. It was concluded that these were morphological stages in the development of the spermatozoa and that all normal bulls show the same stages.

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THE EFFECT OF THYROPROTEIN ("PROTAMONE") ON MILK PRODUCTION AND ON SOME OF THE CONSTITUENTS OF THE MILK AND BLOOD OF DAIRY COWS

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Ohio Agricultural Experiment Station

COMPARATIVELY little experimental work has been reported concerning the effect of thyroprotein on milk composition. Numerous reports, however, have appeared in the literature regarding its effect on milk and fat production. Van Landingham *et al.* (1944) have reported a 33 percent decrease in the ascorbic acid content of the milk of thyroprotein fed cows. Archibald (1945) reports a consistent decrease in casein, and a roughly proportional increase in the lactalbumin and globulin of the milk of thyroprotein fed cows.

In view of the recent interest in "Protamone"[2] (an iodinated casein product) and its proposed inclusion in dairy rations, it seemed desirable to investigate its effect on some of the constituents of blood and milk when fed to dairy cows.

Experimental Methods

Carotene and Vitamin A

Plasma vitamin A and carotene were determined by the method of Kimble (1939). In samples containing carotene in excess of 300 micrograms per 100 ml. the vitamin A was determined by the method of Boyer, Phillips and Smith (1944). The carotene and vitamin A in milk were determined by essentially the same method described by Boyer, Spitzer, Jenson and Phillips (1944) except that the saponification was carried out by refluxing in a boiling water bath for ten minutes instead of the cold saponification. A few minor modifications were also made in the extraction process.

Ascorbic Acid

Ascorbic acid was determined by the macro method of Mindlin and Butler (1938). All colorimetric determinations were made by using the Evelyn Photoelectric colorimeter.

Thiamin

Milk thiamin was determined by an adaptation of the method of Hennessy and Cerecedo (1939) using a Coleman Photofluorometer.

[1] The technical assistance of Mrs. Louise Skinner, who made the riboflavin and thiamin analyses, is gratefully acknowledged.

[2] Supplied by Cerophyl Laboratories, Kansas City, Missouri.

Riboflavin

Milk riboflavin was determined by a fluorometric method. The milk samples were prepared for reading in the fluorometer using a method described by Holmes (1945) as follows:

Twenty-five cc. of milk are added slowly to 50 cc. of the acetone and filtered. Thirty-five cc. of the filtrate are placed in an 100-cc. amber volumetric flask, and 5–8 drops of 4 percent $KmnO_4$ solution added to produce a

TABLE 1. PERTINENT DATA CONCERNING INDIVIDUAL JERSEY COWS USED IN TRIAL 2

Cow No.	Age, yr.-mo.	Initial weight, July 1, lb.	Protamone fed daily, gm.	Stage of lactation,* days	Stage of gestation,* days
		Experimental Group			
706J	5– 2	748	14	311	151
649J	5– 8	849	16	184	49
757J	3– 1	806	15	236	162
Average	4– 7	801	15	244	121
		Control Group			
711J	4– 1	908	0	196	59
675J	5– 1	775	0	287	127
760J	2–10	779	0	241	69
Average	3– 8	821	0	241	85

* At conclusion of experiment October 31, 1945.

definite pink color for at least 2–3 minutes; followed by enough cold hydrogen peroxide to completely discharge the pink color. Approximately 40 cc. of acetone are added and the flask carefully shaken and then set aside for 5–10 minutes when enough acetone is added to make 100 cc. Allow to stand for a few minutes until the precipitate settles and filter. The riboflavin in the filtrate is then determined by means of a Coleman photofluorometer.

Experimental Results and Discussion

Trial 1

Four Jersey and 4 Holstein cows in late lactation were used in the initial trial. Two cows in each breed served as controls and the other 2 cows of each breed were fed "Protamone." The Jerseys received 15 grams of "Pro-

TABLE 2. THE EFFECT OF "PROTAMONE" FEEDING ON MILK PRODUCTION AND BUTTERFAT PERCENTAGE

Date, 1945	Milk			Butterfat			4% Milk*		
	Cont. lb.	Expt. lb.	Difference, percent	Cont. percent	Expt. percent	Difference, percent	Cont. lb.	Expt. lb.	Difference, percent
Control Period									
June 27–July 3	21.6	25.8	+19.4	5.2	4.7	− 9.6	24.4	28.5	+12.2
July 4–10	21.5	25.4	+18.2	5.0	4.7	− 6.0	24.8	28.3	+14.1
Average	21.6	25.6	+18.8	5.1	4.7	− 7.8	24.6	28.4	+13.2
Experimental Period (Rate of grain feeding adjusted weekly)									
July 11–17	20.9	25.1	+19.4	5.9	5.3	−10.2	26.8	30.0	+11.9
July 18–24	19.8	25.6	+29.3	5.5	5.8	+ 5.5	24.3	32.4	+33.3
July 25–31	19.1	26.1	+36.6	5.6	5.7	+ 1.8	23.7	32.8	+38.4
Aug. 1– 7	18.2	25.6	+40.7	5.7	5.6	− 1.8	22.9	31.8	+38.9
Aug. 8–14	17.7	24.4	+37.8	4.9	4.7	− 4.1	20.2	27.1	+34.2
Aug. 15–21	16.6	23.8	+43.4	5.9	5.8	− 1.7	21.3	30.2	+41.8
Aug. 22–24	15.9	22.3	+40.2	5.3	5.4	+ 1.9	19.0	26.9	+41.6
Average	18.3	24.7	+35.2	5.6	5.5	− 1.2	22.6	30.1	+34.3
Control Period									
Aug. 25–28	16.2	21.7	+34.0	5.5	5.3	− 3.6	19.9	26.0	+30.7
Aug. 29–Sept. 4	15.1	16.9	+11.9	5.8	5.2	−10.3	19.2	20.0	+ 4.2
Sept. 5–11	15.1	17.2	+13.9	5.9	4.9	−16.4	19.4	19.5	+ 0.5
Sept. 12–18	15.2	15.8	+ 3.9	6.9	6.6	− 4.4	21.9	22.9	+ 1.0
Average	15.4	17.9	+15.9	6.0	5.5	− 8.7	20.1	22.1	+ 9.9
Experimental Period (Rate of grain feeding held constant)									
Sept. 19–25	14.6	15.5	+ 5.9	6.1	5.1	−16.4	19.2	17.9	− 6.8
Sept. 26–Oct. 2	13.7	16.4	+19.7	6.7	6.0	−10.4	19.3	21.3	+10.4
Oct. 3– 9	12.8	15.0	+17.2	7.0	6.9	− 1.4	18.6	23.2	+24.7
Oct. 10–16	12.3	14.2	+15.5	7.5	6.8	− 9.3	17.8	20.3	+14.0
Oct. 17–23	11.6	14.0	+20.7	6.8	6.2	− 8.8	16.5	18.7	+13.3
Oct. 24–30	11.9	13.5	+13.5	6.6	6.4	− 3.2	16.5	18.3	+10.9
Average	12.8	14.8	+15.4	6.8	6.2	− 8.3	17.9	20.0	+11.1
Control Period									
Oct. 31–Nov. 6	10.1	12.4	+22.8	6.3	7.6	+20.3	13.6	19.1	+40.4
Nov. 7–13	9.8	9.5	− 3.1	6.6	6.5	− 1.5	13.7	13.1	− 4.4
Nov. 14–20	9.1	8.8	− 3.3	5.6	6.1	+ 8.9	11.3	11.6	+ 2.6
Average	9.7	10.2	+ 5.5	6.2	6.7	+ 9.2	12.7	14.6	+12.9

* The Gaines formula was used for converting milk to 4 percent milk (0.4M+15F=4 percent milk).

tamone" daily and the Holsteins 20 grams daily. Before "Protamone" feeding was started three samples of both blood and milk were taken for analysis. "Protamone" feeding was begun November 9, 1944. On December 28, 1944 the groups were reversed and "Protamone" was then fed to the cows which previously had served as controls. "Protamone" feeding was terminated on January 23, 1945.

Analyses of both blood plasma and milk for vitamin A, carotene and ascorbic acid at frequent intervals revealed no differences between the

TABLE 3. THE EFFECT OF "PROTAMONE" FEEDING ON PULSE, RESPIRATION AND BODY WEIGHT

Period	Date, 1945	Pulse, beats per min.		Respiration, per min.		Body wt. (lbs.)	
		Control	Expt.	Control	Expt.	Control	Expt.
Control	7/12	66	66	33	31	850	829
Experimental	8/23	62	77	39	48	840	766
Control	9/12	69	71	39	41	861	792
Experimental	10/30	65	78	33	46	865	763
Control	11/14	63	64	28	32	875	822

groups except that the vitamin A in both blood and milk of the Holstein cows appeared to be decreased during the "Protamone" feeding period.

That the "Protamone" used was biologically active was indicated by its effect on milk production. During "Protamone" feeding an increase in milk production occurred, followed by a rapid decline in milk production when "Protamone" feeding was terminated. No noticeable difference in the fat percentage of the milk was observed at any time.

Trial 2

In June 1945, six Jersey cows were selected three of which were fed "Protamone" while three served as controls. These cows were taken off pasture and kept in the barn. "Protamone" was fed at the rate of approximately 1 gram per 53 pounds of body weight (approximately 15 grams daily). Hay was fed from the same source throughout most of the experiment. Data concerning individual cows are shown in table 1.

"Protamone" feeding was started on July 10, 1945 after a preliminary period during which blood plasma and milk vitamin A, carotene, and ascorbic acid and milk thiamin and riboflavin were determined at approximately weekly intervals. These determinations were made at similar intervals throughout the experiment on individual cows. Average values shown

TABLE 4. THE EFFECT OF "PROTAMONE" FEEDING ON THE BLOOD PLASMA CAROTENE, VITAMIN A AND ASCORBIC ACID CONTENT

Date, 1945	Carotene, micrograms percent		Vitamin A, micrograms percent		Ascorbic Acid, micrograms percent	
	Control	Expt.	Control	Expt.	Control	Expt.
Control Period						
June 13	1415	1062	25.8	24.6	0.54	0.56
June 26	795	694	31.8	29.8	0.47	0.46
July 3	593	475	28.8	26.2	0.47	0.47
July 10	508	395	25.8	25.0	0.51	0.53
Experimental Period						
July 17	452	314	27.9	24.6	0.51	0.59
July 24	405	227	20.6	21.8	0.48	0.39
August 4	377	183	24.9	19.8	—	0.63
August 14	327	179	28.0	24.8	0.54	0.56
August 24	398	268	28.4	23.4	0.51	0.51
Control Period						
August 31	378	235	22.7	20.1	0.55	0.46
September 13	323	231	25.2	27.1	0.50	0.55
Experimental Period						
September 26	286	237	22.7	22.7	0.50	0.50
October 9	295	200	20.3	15.6	0.60	0.56
October 16	301	193	22.9	19.5	0.59	0.52
October 29	497	343	25.9	16.2	0.60	0.55
Control Period						
November 13	523	385	28.9	25.5	0.52	0.58

in the tables were obtained by averaging the individual determinations and were not made on composite samples of the groups. At the beginning of the experiment, the grain ration was adjusted so that all cows in both groups received 1 pound of grain for each 3 pounds of milk produced. This was adjusted every week during the first half of the experiment. "Protamone" feeding was terminated on August 23, 1945 after 44 days of feeding. A three-week control period followed and "Protamone" feeding was resumed on September 20, 1945 on the same basis as before. During this second phase of the experiment, however, the grain feeding was held constant at the 1:3 ratio based on the level of production on September 20. "Protamone"

TABLE 5. THE EFFECT OF "PROTAMONE" FEEDING ON THE CAROTENE, VITAMIN A AND ASCORBIC ACID CONTENT OF MILK

Date, 1945	Carotene, micrograms percent		Vitamin A, micrograms percent		Ascorbic Acid, milligrams percent	
	Control	Expt.	Control	Expt.	Control	Expt.
Control Period						
June 25	30.9	36.4	17.2	19.9	1.78	2.06
July 2	26.5	22.6	16.8	16.5	1.73	1.91
July 9	25.5	19.5	14.6	15.5	2.13	2.31
Experimental Period						
July 18	23.5	18.5	16.2	18.5	2.00	1.95
July 25	19.4	16.2	15.4	17.8	1.92	1.79
August 3	17.0	13.7	14.7	15.7	1.67	1.90
August 13	19.0	13.0	14.0	15.4	2.09	2.18
August 23	22.1	15.7	17.2	20.0	2.03	2.11
Control Period						
August 30	18.1	14.2	13.5	18.5	1.74	2.34
September 14	18.7	15.3	15.3	21.1	1.94	2.21
Experimental Period						
September 27	13.9	9.4	15.4	17.3	2.09	2.01
October 9	17.9	12.6	12.6	15.5	2.05	1.94
October 17	17.7	12.1	14.0	17.5	2.06	1.99
October 30	27.6	18.8	17.1	17.5	1.99	1.71
Control Period						
November 14	36.4	26.2	17.0	21.7	1.86	2.13

feeding was terminated on October 31, 1945 after a 41–day feeding period. The previously mentioned determinations were continued for a three-week control period at the end of the second experimental period.

The milk production and butterfat percentage data are shown in table 2. It will be noted that a much smaller response in milk production resulted when the grain intake was limited. The effect of "Protamone" feeding on body weight, pulse rate, and respiratory rate is indicated in table 3. Marked increases in pulse and respiratory rate and losses in body weight accompanied the feeding of "Protamone" in both periods.

The results of the effect of "Protamone" feeding on blood plasma vitamin

TABLE 6. THE EFFECT OF "PROTAMONE" FEEDING ON THE THIAMIN AND RIBOFLAVIN CONTENT OF MILK

Date, 1945	Thiamin, micrograms percent		Riboflavin, micrograms percent	
	Control	Expt.	Control	Expt.
Control Period				
June 9	30	39	—	—
June 25	29	38	—	—
July 2	33	41	—	—
July 9	31	42	—	—
Experimental Period				
July 18	29	31	162	151
July 25	37	28	162	150
August 3	35	28	182	169
August 13	31	26	157	149
August 23	37	27	165	145
Control Period				
September 5	33	45	173	167
September 14	35	50	182	170
Experimental Period				
October 17	38	33	237	195
October 24	35	34	222	177
October 30	38	31	216	168
Control Period				
November 19	34	52	206	215
November 26	33	46	188	189

A, carotene, and ascorbic acid are presented in table 4. The results of similar analyses on milk are shown in table 5. There was no significant difference between the two groups at any time with respect to these three vitamin constituents of blood and milk, except that a variable decrease in blood vitamin A occurred during the second "Protamone" feeding period, which was followed by an increase after "Protamone" feeding was stopped.

Table 6 shows the effect of "Protamone" feeding on the thiamin and riboflavin content of the milk. A decrease in the milk thiamin was observed in both "Protamone" feeding periods followed by rapid increases during the control periods. The same result was obtained when the daily secretion of

thiamin in the milk was calculated. No decrease in milk riboflavin occurred except in the second "Protamone" feeding period when the grain intake was limited. A marked increase in the milk riboflavin followed the termination of "Protamone" feeding after the second experimental period. This was true of the total daily excretion in the milk as well as on the basis of micrograms per 100 ml. It should be pointed out, however, that these decreases are ex-

TABLE 7. THE EFFECT OF "PROTAMONE" FEEDING ON THE TOTAL PROTEIN CONTENT OF MILK

Date, 1945	Percent total protein*	
	Control	Experimental
Experimental Period		
August 17	3.10	2.30
August 24	3.16	2.94
Control Period		
August 30	3.91	2.96
September 18	3.63	3.19
Experimental Period		
September 27	3.93	3.81
October 10	4.08	4.21
October 17	4.20	4.03
October 30	4.15	3.88

* Formula for calculating protein—(6.38×N=P).

pressed in relation to the control group. Actual values did not fall below the normal range.

During the last part of the first experimental period, and continuing through the remainder of the experiment, frequent determinations were made, by the Kjeldahl method, of the total protein of the milk. As shown in table 7 no definite effect on the total protein content of milk could be attributed to "Protamone" feeding. The various protein fractions were not determined in this experiment. Archibald (1945) found that "Protamone" feeding lowered the casein content of milk but this was partially compensated for by increased lactalbumin and globulin values.

Mammary Gland Impermeability to the Thyroid Hormone

Reineke and Turner (1944) have reported that the mammary gland is non-permeable to the thyroid hormone. In connection with the previously

described experiment it was decided to determine the effect on heat production in rats, of feeding the milk of "Protamone" fed cows.

Ten male rats averaging 180 grams in weight were selected and three preliminary post-absorptive basal metabolism determinations were made using a closed system metabolism apparatus described by Hibbs *et al.* (1945). Beginning July 16, 1945 mineralized milk composited from all three of the

TABLE 8. THE EFFECT OF FEEDING MILK FROM "PROTAMONE" FED COWS ON THE B.M.R. OF MALE RATS

Rat no.	Normal B.M.R. 7/16/45	B.M.R. 8/1/45	Percent difference	B.M.R. 8/21/45	Percent difference
		Fed Milk from "Protamone" Cows Continuously			
1	809	814	+ 0.6	790	+ 2.3
2	765	832	+ 8.8	828	+ 8.2
4	792	733	− 7.7	763	− 3.7
7	753	848	+12.6	829	+10.0
9	765	805	+ 5.2	805	+ 5.2
Average	777	806	+ 3.9	803	+ 4.4
		Fed Milk from "Protamone" Cows July 16 to August 1, Fed Milk from Normal Cows August 1 to August 21			
3	706	825	+16.8	785	+11.2
5	795	872	+ 9.7	846	+ 6.4
6	820	825	+ 0.6	745	− 9.1
8	727	820	+12.6	686	+ 5.6
10	740	813	+ 9.9	780	+ 5.4
Average	758	831	+ 9.9	768	+ 1.4

B.M.R. = Calories per square meter of body surface per 24 hours.

cows fed "Protamone" was fed exclusively ad libitum to all ten rats. Each rat served as its own control. On August 1 another metabolism determination was made. At this point one half of the rats were retained on milk from the "Protamone" fed cows while the other half were switched over to normal cows' milk.

As indicated in table 8, although there appeared to be a slight increase in the metabolism of rats fed milk from "Protamone" fed cows, the differences are within the limits of experimental error and are not considered to be of significance.

Discussion

That the "Protamone" used in the last two trials was biologically active is indicated by its effect on milk production, body weight, pulse, and re-

spiratory rate. The fact that a greater increase in milk production resulted when the grain intake was increased according to production than when held constant suggests that the nutrient intake must be higher than normal to get the full benefit of "Protamone" on milk production. Our results suggest that a still closer ratio of grain to milk than 1:3 should be fed in order to help prevent the weight losses which were encountered. It is of interest in this connection to note that, when "Protamone" feeding was terminated in the period in which grain feeding was limited, a marked increase in butterfat percent and 4 percent milk occurred before the usual rapid decline in production. This observation is further indication that the relation of dosage of "Protamone" and nutrient intake needs further study. A preliminary report by Moore (1946) is of interest in this connection.

In trial 2 no consistent difference could be detected in the carotene or ascorbic acid content of the blood or milk of "Protamone" fed cows as compared with control cows; however, a decrease in blood vitamin A occurred in the second experimental period but no decrease was observed in milk vitamin A. The reason for the decrease observed in both the milk and blood vitamin A of Holstein cows in trial 1 is not readily explainable unless it was due to the higher dosage (20 grams) given to the Holsteins. The amount of vitamin A liver storage doubtless would influence the time of appearance of low blood levels. In long periods of "Protamone" feeding it is possible that deficiency levels of vitamin A might be encountered.

There is no apparent explanation for the difference in milk ascorbic acid results between ours and those of Van Landingham *et al.* (1944). The fact that we found no differences in the blood ascorbic acid content serves as a check on our milk data.

Our observations regarding the effect of "Protamone" feeding on thiamin and riboflavin in milk are of interest especially since the cow normally has no dietary requirement for these vitamins. It is assumed that the milk changes are reflections of similar changes in the blood since the total daily output in the milk varied according to a similar pattern, as did the actual amounts expressed as micrograms per 100 ml. That thiamin excretion in the milk decreased during "Protamone" feeding regardless of the nutrient intake employed is further indication that increased nutrient intake as well as increased thiamin intake may be required in "Protamone" feeding. Apparently the cows were in a hypothyroid condition after termination of "Protamone" feeding as indicated by the fact that thiamin increased to above the normal level during the control period.

In the period of normal grain feeding no change was noted in the riboflavin content of the milk of "Protamone" fed cows; however, when the grain

was limited the riboflavin picture was similar to that of thiamin. The decrease in milk riboflavin of these cows was followed by a marked increase after "Protamone" feeding was terminated. This observation suggests that the riboflavin changes due to "Protamone" may not occur at as high a nutrient intake as do the changes in thiamin.

Although the changes in both thiamin and riboflavin of milk occurred at a level at which no clinical deficiency symptoms would be expected these findings may be of significance in long periods of "Protamone" feeding where thiamin and riboflavin deficiency might enter into the picture. Williams *et al.* (1943), report that the thyroid hormone is less effective in promoting the metabolic activity of the organism in a state of thiamin deficiency. Also it is a well known fact that thyroxin secretion raises the requirement for thiamin.

It is known that riboflavin is involved in the absorption of carbohydrates from the intestine by the process of phosphorylation. Ponz (1944) reports that thyroxine injections caused an increase in riboflavin excretion in the free form and a decrease in the phosphorylated form. This is attributed to the failure of phosphorylation or to dephosphorylation of the flavin enzymes.

This phase of the problem will need further study before the significance of these observations can be fully understood.

Summary

The feeding of "Protamone" at the rate of 1 gram per 53 pounds of body weight to dairy cows resulted in the following observations:

(1) An increase in milk production which was dependent, to a large extent, upon the nutrient intake of the cow. This increase was followed by a rapid decline to below the normal level after termination of "Protamone" feeding. Considerable individual variation was noted in milk production responses. No changes in butterfat percent due to "Protamone" were found.

(2) A decrease in body weight and increases in pulse and respiratory rates.

(3) No changes in milk or blood plasma, carotene, or ascorbic acid. Frequent decreases in both blood and milk vitamin A of individual "Protamone" fed cows were observed. These results are not sufficiently consistent to be conclusive but indicate that prolonged "Protamone" feeding may affect the vitamin A requirements.

(4) No change in milk total protein.

(5) A marked decrease in milk thiamin during "Protamone" feeding at both levels of nutrient intake employed. During the control periods thiamin increased to above normal levels. No change in the riboflavin content of the milk occurred during the period of normal grain feeding but a decrease did

occur in the experimental group during the period in which grain feeding was limited. This decrease was followed by a rapid increase during the control period. While these changes in both riboflavin and thiamin occurred within the normal range, as indicated by the control group, they may be indications that deficiency levels may be encountered in prolonged "Protamone" feeding.

(6) Basal metabolism tests on rats fed exclusively on milk from "Protamone" fed cows indicated that if the hormone is secreted by the mammary gland it is in amounts too small to detect by this method. The possibility of the existence of thiamin and riboflavin deficiency during long periods of "Protamone" feeding is discussed. Vitamin A deficiency might likewise result from "Protamone" feeding if the dosage is too high and when fed during the winter months when the Vitamin A intake is likely to be low.

In view of these results it would seem that great care should be exercised in feeding "Protamone" to dairy cows until more is known of its physiological effect on the cow. The greatest possibility for its use may lie in the treatment of hypothyroid[3] individuals rather than in general feeding to all milking cows in the herd. This involves the development of a technique for readily determining the state of thyroid metabolism in the individual cow.

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[3] The authors wish to call attention to a misprint in the abstract of a paper presented at the 1946 meetings of the American Society of Animal Production in Chicago. On page 401 of the Nov. 1946 issue of this JOURNAL in the next to the last line of the abstract, the word *hyperthyroid* appears. This should read *hypothyroid*.

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GENETIC AND ENVIRONMENTAL CORRELATIONS BETWEEN GROWTH RATES OF BEEF CATTLE AT DIFFERENT AGES[1]

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FEW data are available from which to determine the relative effects of heredity and environment on the growth rates of beef cattle. Knapp and Nordskog (1946) made a preliminary study of growth in beef cattle in which they found it was highly heritable, as measured by weights and feed lot gain. Their data were limited but indicated that, even allowing for large errors of estimate, the heritability of growth was very high. It is the purpose of this paper to present the results of another study of heritability of growth. The method used differs from those used in the preceding paper and the results should throw more light on the results obtained previously.

Source of Data

All animals used in these studies were produced at the U. S. Range Livestock Experiment Station, Miles City, Montana, and the North Montana Branch Station, Havre, Montana. There were 329 steers from the Miles City station and 93 steers from the Havre station. There were 43 different sires represented in the 2 herds, but 3 sires were progeny tested during 2 years at Miles City, and 6 sires used at Miles City were also used at Havre.

At both stations, only those years when the animals were fed at least 252 days were used. At Miles City, they were from 1937 to 1945 inclusive, but at the Havre station they included only the years of 1940–41, 1942–43, and 1944–45.

At Miles City, the calves were born on the range during April and May and weaned about the 20th of October each year. In every year except the last (1944–45) the calves were started on feed immediately after weaning. The feed consisted of concentrates (corn, beet-pulp, bran, linseed meal) in several ratios, but since 1940–41 the same concentrate mixture was fed every year. Alfalfa hay was fed in all years.

At Havre, the calves were dropped in small pastures near headquarters and trailed 25 miles to summer range about June 1st each year. The calves and cows were trailed back to headquarters again the last week of October and the calves were weaned. From each sire group 8 random selected steers

[1] This manuscript is a contribution from the beef cattle breeding improvemnt program conducted cooperatively by the Bureau of Animal Industry, U. S. Department of Agriculture and the following experiment stations: Colorado, Idaho, Montana, Nebraska, North Dakota, Oregon, South Dakota, Utah, Washington and Wyoming.

were shipped to Bozeman, where they were placed on feed after a 2 or 3 weeks' preliminary feeding period. The feeds consisted of barley, beet pulp, linseed meal, and alfalfa or native grass hay.

The number of sire groups, number of steers, and average gain for each 84-day period are shown in table 1.

TABLE 1. NUMBER OF SIRE GROUPS, NUMBER OF STEERS, AND AVERAGE GAIN OF STEERS FOR EACH 84-DAY PERIOD AT MILES CITY AND HAVRE STATIONS

Station	Year	Number of sire groups	Number of steers	Average gain for each 84-day period (pounds)		
				Period 1	Period 2	Period 3
Miles City	1937–38	3	32	137.6	170.6	169.6
	1938–39	3	36	99.4	155.4	174.2
	1939–40	4	31	91.9	168.5	169.2
	1940–41	3	24	114.5	164.8	176.8
	1941–42	8	62	127.2	191.8	187.2
	1942–43	6	45	119.2	182.4	191.5
	1943–44	6	46	129.0	184.7	152.8
	1944–45	7	53	126.9	187.0	184.5
	Totals and averages	40	329	120.0	178.5	177.0
Havre	1940–41	2	16	137.3	215.6	162.1
	1942–43	5	37	136.8	207.7	184.2
	1944–45	5	40	98.7	176.6	159.4
	Totals and averages	12	93	120.5	195.7	169.7

Methods of Analysis

An adaptation of the method of analysis used by Hazel, Baker, and Reinmiller (1943) was employed to analyze these data. For the convenience of the reader, the writers will review their methods as they were adapted to the beef cattle data.

A number of factors acting simultaneously during the growing period cause variation in the observed growth rates of animals. Each source of variation is quantitative and estimates of each source may be made. The growth of each calf may be divided into two sources of variation: (1) Genetic, *G*, composed of the average effects of all genes affecting growth rate, and (2) a residual effect, *E*, which includes the effects of environment peculiar to each individual calf plus the effects of any dominance and epistasis among

the genes affecting growth race. Thus, the growth rate during any period, X, is equal to:

$$X = G + E$$

and the variance, V, of growth in any period is:

$$V_X = V_G + V_E$$

The covariance, CV, between any two periods can likewise be divided into:

$$CV_{X1X2} = CV_{G1G2} + CV_{E1E2}$$

From these equations, the correlation of the effects of one source of variation (either G or E) between one period and another may be calculated as follows:

$$r_{G1G2} = \frac{CV_{G1G2}}{\sqrt{(V_{G1})(V_{G2})}}$$

The first step consists in breaking down the intra-year and station variance into the two mean squares: between sire groups and within sire groups. By the use of the method of Winsor and Clarke (1940) these mean squares may be further analyzed into their two components V_S and V_I. Since this population resulted from random selected cows (within age groups) the genetic variance in V_S is $\frac{1}{4}$ and in V_I is $\frac{3}{4}$. Based on this assumption the genetic and environmental variances and covariances may be calculated as follows:

$$V_G = 4V_S \qquad CV_G = 4CV_S$$

$$V_E = V_I - 3V_S \qquad CV_E = CV_I - 3CV_S$$

Results and Discussion

The results of the analyses of variance and covariance for gains in the three 84-day periods are summarized in table 2. The gains for the three

TABLE 2. ANALYSES OF VARIANCE AND COVARIANCE FOR GAINS DURING THREE 84-DAY PERIODS

Source of variance	df	Theoretical composition[1]	Mean squares			Covariances		
			X_1	X_2	X_3	X_1X_2	X_1X_3	X_2X_3
Total: Intra year & station	411	$A+\frac{N(K-1)}{NK-1}B$	354.62	652.30	667.99	123.52	87.37	248.28
Between sire groups	41	$A+KB$	419.51	1314.37*	1733.51*	293.66	206.76	838.41
Within sire groups	370	A	347.43	578.93	549.92	104.67	74.15	182.89

* Significant, P is less than .01.

[1] N is the total number of animals used in this study, K is the average number of animals in each sire group, 8.12.

periods are designated as X_1, X_2, and X_3. These data were analyzed on an intra-station and year basis (differences due to stations and years being eliminated). The results of the analyses indicate significant sire differences occurred in the second and third 84-day periods (P is less than .01), but not in the first period (P is greater than .05).

TABLE 3. COMPONENTS OF VARIANCES AND COVARIANCES OF GAINS AND BETWEEN GAINS FOR THREE 84-DAY PERIODS

Source of variation	X_1	X_2	X_3	X_1X_2	X_1X_3	X_2X_3
Sire variance (V_S)	8.88	90.57	145.76	23.27	16.33	80.73
Individual variance (V_I)	347.43	578.93	549.92	104.67	74.15	182.89

The gross correlation between periods 1 and 2 was 0.26, periods 1 and 3, 0.18, and periods 2 and 3, 0.39. All of these correlations are statistically significant. These correlations represent the relationship of both heredity and environment as these factors affect the growth of the calf.

TABLE 4. GENETIC, ENVIRONMENTAL, AND TOTAL OR PHENOTYPIC VARIANCES AND COVARIANCES OF GAINS FOR THE THREE PERIODS

Source of variation	Symbol	Periods		
		1	2	3
Genetic	$V(G_1)$	35.52	93.08	65.32
Genetic	$V(G_2)$		362.28	322.92
Genetic	$V(G_3)$			583.04
Environmental	$V(E_1)$	320.79	34.86	25.16
Environmental	$V(E_2)$		307.22	−59.30
Environmental	$V(E_3)$			112.64
Phenotype	$V(X_1)$	356.31	127.94	90.48
Phenotype	$V(X_2)$		669.50	263.62
Phenotype	$V(X_3)$			695.68

The variances and covariances in table 2 were further broken down into their components using the methods of Winsor and Clarke (1940). The results are shown in table 3. In these data, the average number of steers per sire was 8.12. These components were used to derive the hereditary and environmental variances shown in table 4. The total variances (V_X) for each period were obtained by adding the two sources of variance.

By the use of these variances and covariances the genetic and environmental correlations may be calculated. These correlations are shown in fig-

ure 1. These results compare favorably with those observed in swine by Hazel *et al.* (1943) except for the lower environmental correlations between the three periods. In figure 1 are also shown the path coefficients for the genetic and environmental influences on the gains for the three periods. The gains during the first period are largely controlled by environmental causes. In the second period, genetics and environment have about equal influence, but in the third period, the gains are largely determined by hereditary influences. The heritability of gain as estimated by the path coefficients (the square of the path coefficient) is for each of the three periods 10, 54, and 84 percent.

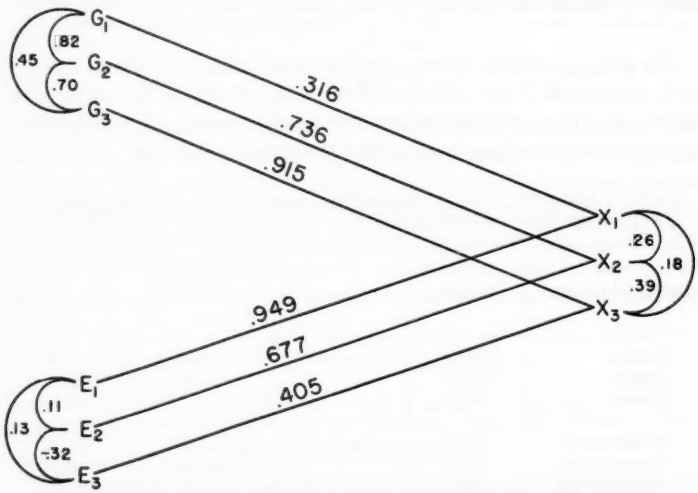

Figure 1. Path-coefficient diagram to show the genetic and environmental influences on the gains for each of the three periods.

The reason for the negative environmental correlation between periods 2 and 3 is clear. The environmental correlations indicate that there was little effect of this source of variation in determining gains from one period to another.

The gains in the three periods may also vary in the extent to which they affect the growth rate over the entire period (252 days). Since growth rate over the entire 252-day period is the sum of the gains of the three 84-day periods, the correlation between the genetic growth for the entire 252-day period (G_T) and the phenotypic growth for the individual for each period (X_1, X_2, or X_3) should give a fair estimate of the efficiency of each of the

three periods as a basis of selection for genetic superiority. These correlations were calculated as follows:

$$r_{G_T X_1} = \frac{CV_{G_T X_1}}{\sqrt{(V_{G_T})(V_{X_1})}} = .23$$

$$r_{G_T X_2} = .69$$

$$r_{G_T X_3} = .85$$

These correlations definitely indicate the progressively better measure of genetic growth as the feeding period progresses. Beef calves as they go on feed do not gain at first to the limit of their genetic growth potentialities but as the feeding period progresses the growth curves will tend to spread. In swine, Hazel *et al.* (1943) found that the second period gave the better measure of genetic growth.

Hazel *et al.* (1943) suggest that the most logical measure of genetic growth over the entire period (G_T) is the observed growth over the same period (X_T) where

$$X_T = X_1 + X_2 + X_3$$

Thus:

$$r_{G_T X_T} = \frac{V_{G_T}}{\sqrt{(V_{G_T})(V_{X_T})}} = .85$$

In this case, there was a very high correlation between the genetic and observed effects. Since this correlation squared is a measure of heritability of gains over the entire period, this result confirms the results previously reported by Knapp and Nordskog (1946).

A multiple correlation between the total genetic influence (G_T) and the observed gains (X_1, X_2, and X_3) for the three periods gives additional information on the total genetic influence. The multiple correlation coefficient was found to be:

$$R_{G_T \cdot X_1 X_2 X_3} = .94$$

From the above analyses, it would seem that genetic superiority of growth may be more easily measured during the latter part of the feeding period. In fact, the results indicate that observations of the gains during the third 84-day feeding period were of equal value to total gain over the entire 252-day feeding period in estimating genetic superiority of growth. However, proper weighting of gain in each of the three periods as shown by the multiple correlation was a better measure than either total gain or gain during

the last 84 days. Knapp *et al.* (1942) suggested individual feeding for the first 168 days and lot feeding for the remaining 84 days in order to reduce the labor of individual feeding over the entire 252-day period. The above study would seem to indicate that individual feeding should be resorted to during the latter part of the 252-day period.

The above study has added further evidence of the generally important influence of heredity in determining gains of beef steers in the feed lot. Obviously, from the results, environmental influences have been reduced to a minimum due to control of the environment within each year of feeding. This study includes over twice as many animals as were used in the previous paper (Knapp and Nordskog, 1946) and therefore greater reliance can be placed in these results.

It is concluded that heredity plays a most important part in determining the gains of calves in the feed lot. Based on this conclusion, the progeny testing of calves for gaining ability seems unnecessary and selections for this ability can be made through comparative feeding tests of the prospective herd sires. However, carcass qualities must necessarily be measured through slaughter tests of the progeny.

Summary

An analysis was made of the gains of 422 steers from 43 different sires at the U. S. Range Livestock Experiment Station, Miles City, Montana, and at the North Montana Branch Station, Havre, Montana. The steers were all fed at least 252 days.

The feeding period was divided into three 84-day periods for the purpose of analysis and the gross correlation between periods 1 and 2 was 0.26, periods 1 and 3, 0.18 and periods 2 and 3, 0.39. All of these correlations were statistically significant. The genetic and environmental correlations assumed to underly these gross correlations were calculated. The genetic influences for each of the three periods were 10, 54, and 84 percent of the variation in gains.

The analysis indicates that there was little environmental correlation between the three periods and that the genetic influence became greater as the feeding period progressed. The correlation between the genetic influence (G_T) for the entire period and the observed growth over the same period was 0.85.

It was concluded that heredity plays a most important part in determining the gains of calves in the feed lot.

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THE EFFECT OF THE NUTRITIONAL PLANE UPON THE REACTIONS OF ANIMALS TO HEAT

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Introduction

THE problem of tropical settlement is closely bound up with the problems of tropical production, not least amongst which is that of animal production. For many purposes it is desirable to have rapid growth of animals, fat animals or very well fed animals. On the other hand, there is a general belief that fat animals "stand the heat" less well than their lean brethren. A theoretical deduction from well-established demonstrations of the "specific dynamic effect" of protein has resulted in a wide-spread supposition that high-protein diets are particularly disadvantageous to animals exposed to a heat stress.

To throw some light on these propositions, we included in our plan of investigations into the climatic physiology of homeotherms, studies of the effects of two types of dietary variation upon the reactions of animals during acute exposures to hot environments. These were: (a) differences in the daily amounts of the same food mixture; (b) differences in the proportions of protein in iso-caloric, adequate diets. This paper reports the general results and conclusions.

The general reactions of these animals to atmospheres of varying temperature and humidity are described in previous reports (Yeates, Lee and Hines, 1941; Robinson and Lee, 1941; Lee and Robinson, 1941; Lee, Robinson, Yeates and Scott, 1945).

Effects of Differences in the Rate of Feeding

General Plan of Experiments

The most extensive studies were made on two breeds of hens, White Leghorns and Australorps. Four healthy day-old chicks of each breed were allowed to partake freely of an adequate mash, while four others of each breed were given only those quantities considered to be the minimum which would ensure a reasonably healthy state. The birds were maintained in this way for 69 weeks. At the end of this time the diets were suddenly reversed and the studies continued for a further 5 weeks.

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Two lambs, (Border Leicester-Merino cross wethers), each eight months old, were given free access to an adequate food mixture, while two others of similar age and weight were given only "maintenance" quantities daily. This was continued for 41 weeks. At the end of this time their diets were also reversed and the studies continued for a further 15 weeks.

A similar experiment was conducted with four Middle White sows, commencing when they were 10 weeks old and lasting for 16 weeks, by which time the well-fed pair were too heavy for our hot-room balance. No reversal of diets was made with these animals.

All the animals were exposed once a week for seven hours to a hot atmosphere. In alternate weeks a hot-wet (D.B. 85° F., W.B. 83.5° F. A.H. 10.3 grs /c. ft.)[2] and a hot-dry (D.B. 105° F., W.B. 86.5° F., A.H. 11.0 grs./c. ft.) atmosphere was employed. Whilst they were still under "normal" conditions in the ante-room, and hourly during their exposure in the hot room, observations were made of the rectal temperature, pulse rate, respiratory rate and weight. No food was given in the hot room, but free water-drinking was permitted.

From the ante-room weight charts (figure 1) it will be seen that the whole of the growth curve was covered in the hens, but that only the lower portion was studied in the sheep and the middle portion in the pigs.

Results Obtained upon Hens

From table 1 it will be seen that the higher rate of feeding resulted in a very highly significant increase of the average rectal temperature, pulse rate, respiratory rate and weight loss of all the hens exposed to hot atmospheres. The increase was more marked in the hot-dry than in the hot-wet atmosphere, the differential effect being highly significant, except in the case of the pulse rate (heat has been shown previously to have little effect upon the pulse rate of hens).

The higher rate of feeding also results in a very highly significant increase of pulse rate and respiratory rate under "normal" temperature conditions, and a significant or highly significant rise in the rectal temperature. With the exception of the pulse rate again, this rise under "normal" temperature conditions is significantly less than that under hot-wet conditions.

In figure 2 it will be seen that, when the diets were reversed, the differential reactions of the two groups of hens changed more quickly than the body weight.

Results Obtained upon Sows

From table 2 it will be seen that the high-plane diet resulted in a highly or

[2] Throughout this paper the contractions D.B. for dry bulb temperature, W.B. for wet bulb temperature and A.H. for absolute humidity will be used. To convert grs./c.ft. to mm. Hg. vapour pressure, multiply by 0.17.

TABLE 1. EXCESS OF THE AVERAGE REACTIONS OF HENS ON HIGH-PLANE DIETS OVER THOSE ON LOW-PLANE DIETS

Reaction	Comparison made and statistical significance		Ante-room (single readings)		Hot-wet atmosphere (average reading during 7 hrs. exposure)		Hot-dry atmosphere (average reading during 7 hrs. exposure)	
			W. Leg.	Aust.	W. Leg.	Aust.	W. Leg.	Aust.
Rectal temp. °F.	Frequency of rel. magnitude	High>low	40	39	29	28	31	31
		High=low	5	5	1	3	0	0
		High<low	17	18	1	0	0	0
	Excess of high over low	Mean excess in °F.	.155±.054*	.173±.061	.519±.051	.397±.047	1.006±.092	1.497±.126
		Level of signif. (P ⩾)	.010	.050	.001	.010	.001	.001
Pulse rate/min.	Frequency of rel. magnitude	High>low	61	61	31	30	31	31
		High=low	0	1	0	1	0	0
		High<low	1	0	0	0	0	0
	Excess of high over low	Mean excess beats/min.	57.8±4.18	63.4±4.41	55.9±5.00	61.0±5.39	61.4±4.71	68.2±7.70
		Level of signif. (P ⩾)	.001	.001	.001	.001	.001	.001
Respiratory rate/min.	Frequency of rel. magnitude	High>low	60	60	31	31	31	30
		High=low	1	1	0	0	0	0
		High<low	1	1	0	0	0	1
	Excess of high over low	Mean excess resps./min.	6.71±.371	7.00±.562	23.1±3.70	32.6±4.27	69.3±5.16	55.1±6.16
		Level of signif. (P ⩾)	.001	.001	.001	.001	.001	.001
Weight loss gms./hr.	Frequency of rel. magnitude	High>low	—	—	25	28	25	28
		High=low	—	—	2	2	2	0
		High<low	—	—	2	0	2	1
	Excess of high over low	Mean excess gms./hr.	—	—	1.38±1.166	2.42±.228	5.93±.707	9.14±.847
		Level of signif. (P ⩾)	—	—	.001	.001	.001	.001

* Variation is expressed in terms of the standard deviation of the mean excess (i.e. standard error).

TABLE 2. EXCESS OF THE AVERAGE REACTIONS OF SOWS ON HIGH-PLANE DIETS OVER THOSE ON LOW-PLANE DIETS

Reaction	Comparison made and statistical significance		Ante-room (single readings)	Hot-wet atmosphere (average reading during 7 hrs. exposure)	Hot-dry atmosphere (average reading during 7 hrs. exposure)
Rectal temp. ° F.	Frequency of rel. magnitude	High>low	14	8	8
		High=low	1	0	0
		High<low	1	0	0
	Excess of high over low	Mean excess in ° F	0.781±.166*	1.49±.129	1.44±.340
		Level of signif. (P>)	.010	.001	.010
Pulse rate/min.	Frequency of rel. magnitude	High>low	11	6	6
		High=low	2	1	1
		High<low	3	1	1
	Excess of high over low	Mean excess beats/min.	5.12±2.12	10.50±3.49	9.88±2.92
		Level of signif. (P>)	.050	.050	.050
Respiratory rate/min.	Frequency of rel. magnitude	High>low	10	8	8
		High=low	2	0	0
		High<low	4	0	0
	Excess of high over low	Mean excess resps./min.	4.38±1.73	94.0±12.0	114±26.6
		Level of signif. (P>)	.050	.001	.010
Weight loss gms./hr.	Frequency of rel. magnitude	High>low	—	8	—
		High=low	—	0	—
		High<low	—	0	—
	Excess of high over low	Mean excess gms./hr.	—	50.9±8.11	—
		Level of signif. (P>)	—	.010	—

* Variation is expressed in terms of the standard deviation of the mean excess (i.e. standard error).

very highly significant rise of the rectal temperature, respiratory rate and weight loss in the hot atmospheres, but that, with pigs, this difference was no greater in the hot-dry than in the hot-wet atmosphere. The rise of pulse rate was less marked, but still significant.

The high-plane diet produced a highly significant rise of rectal temperature in the ante-room, but less marked, though significant, rises of pulse rate and respiratory rate. The increases in rectal temperature and respiratory rate

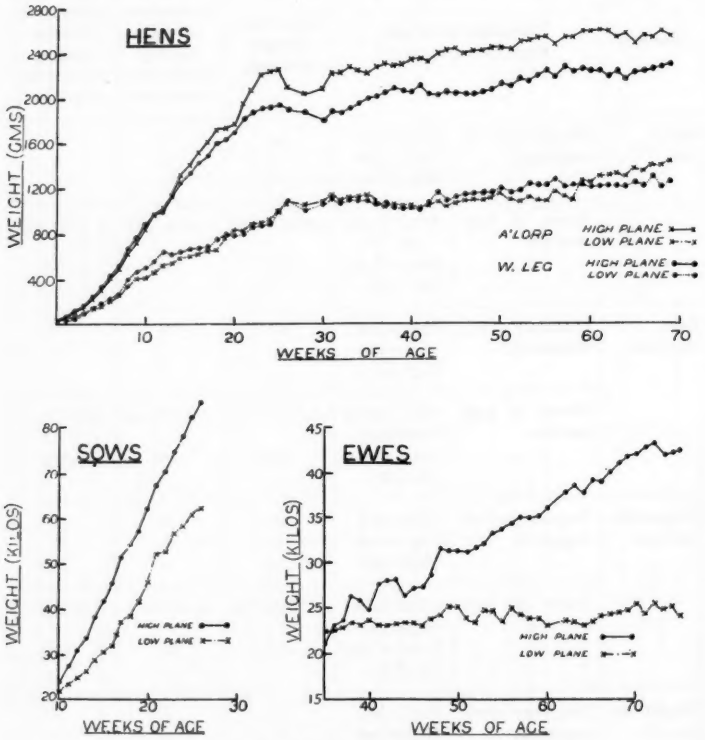

Figure 1. Weight curves of animals studied.

produced by this diet in the hot atmospheres were greater to a very highly significant extent than those produced in the ante-room.

Results Obtained upon Wethers

Table 3 shows that the high-plane diet resulted in very highly significant increases in rectal temperature, pulse rate and respiratory rate in the ante-room, hot-wet and hot-dry atmospheres.

The increases brought about in rectal temperature and pulse rate are no greater, however, in the hot atmospheres than in the ante-room. In the case

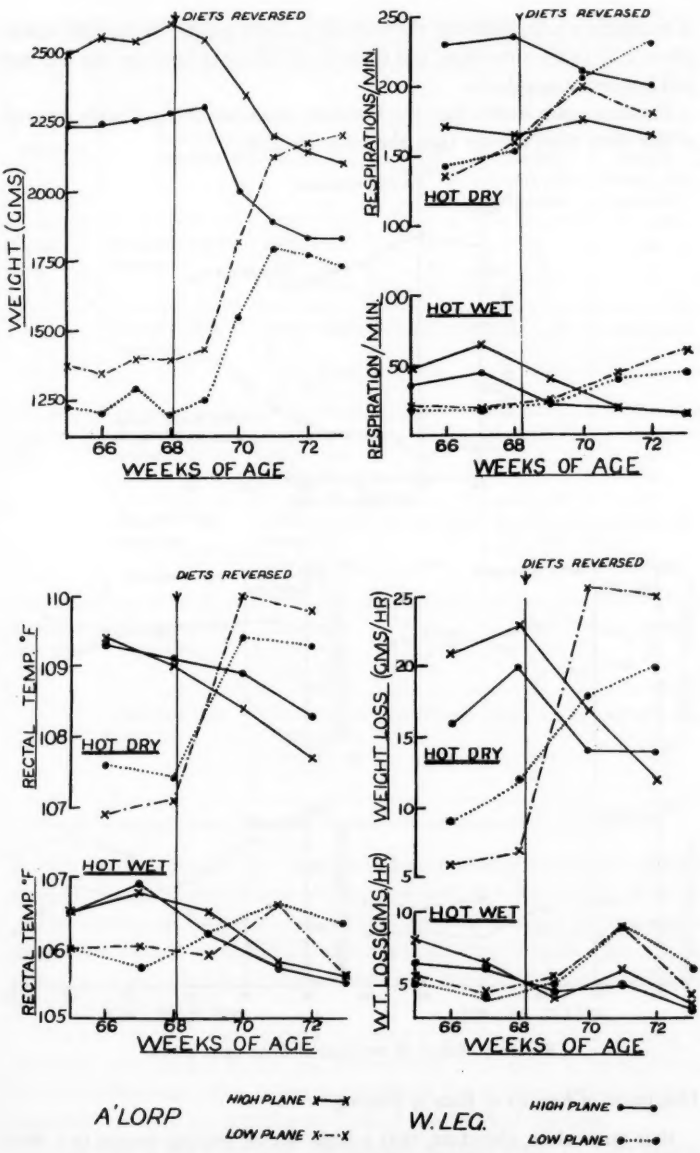

Figure 2. Effect of reversal of diets upon hens.

of respiratory rate, however, the increase is much greater in the hot atmosphere than in the ante-room, but there is no difference between the hot-wet and hot-dry atmospheres.

Figure 3 again shows that the hot-room reactions changed with reversal of the diets more rapidly than the body weights.

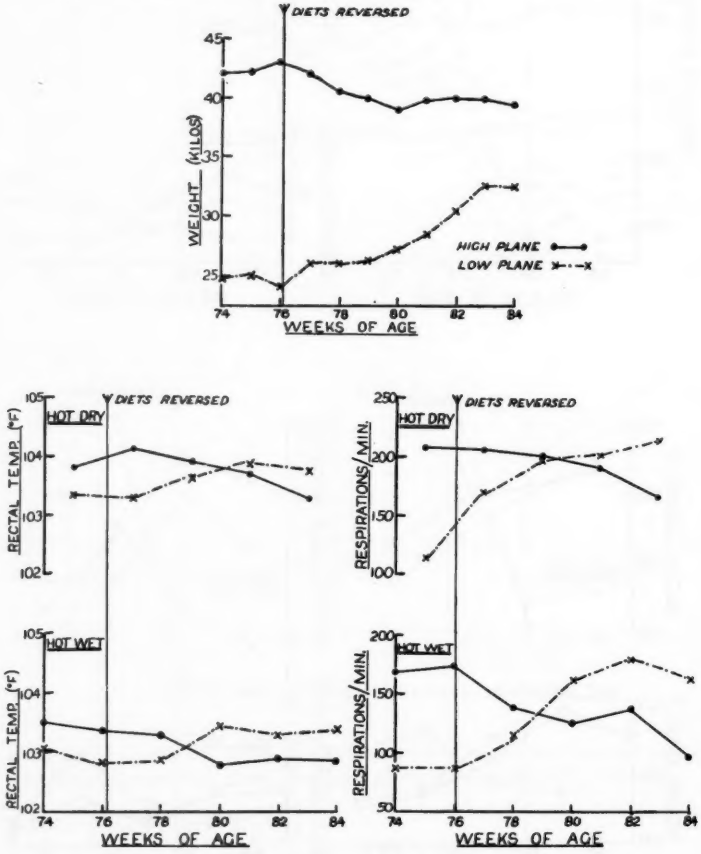

Figure 3. Effect of reversal of diets upon ewes.

Discussion of Results of Rate of Feeding

It is quite clear, therefore, that a high rate of feeding results in a very definite increase in rectal temperature, respiratory rate and rate of water loss

TABLE 3. EXCESS OF THE AVERAGE REACTIONS OF WETHERS ON HIGH-PLANE DIETS OVER THOSE ON LOW-PLANE DIETS

Reaction	Comparison made and statistical significance		Ante-room (single readings)	Hot-wet atmosphere (average reading during 7 hrs. exposure)	Hot-dry atmosphere (average reading during 7 hrs. exposure)
Rectal temp. ° F.	Frequency of rel. magnitude	High>low High=low High<low	37 1 2	19 0 1	19 0 1
	Excess of high over low	Mean excess in ° F. Level of signif. (P>)	0.545±.042* .001	.615±.080 .001	0.720±.090 .001
Pulse rate/min.	Frequency of rel. magnitude	High>low High=low High<low	39 0 1	18 1 1	20 0 0
	Excess of high over low	Mean excesss beats/min. Level of signif. (P>)	17.0±1.69 .001	11.3±1.61 .001	13.8±2.03 .001
Respiratory rate/min.	Frequency of rel. magnitude	High>low High=low High<low	40 0 0	20 0 0	20 0 0
	Excess of high over low	Mean excess resps./min. Level of signif. (P>)	27.8±2.80 .001	101.0±5.45 .001	96.9±2.80 .001

* Variation is expressed in terms of the standard deviation of the mean excess (i.e. standard error).

in all the animals studied, but that the pulse rate is only moderately affected in sows though markedly increased in hens and, to a less extent, in ewes.

The increase of respiratory rate brought about by the high feeding rate is much more marked in the hot atmospheres in all three animals. This is to be expected, as increased respiratory volume is an important thermo-regulatory device in these animals.

The rise in rectal temperature resulting from the high-plane feeding is generally more marked in the hot atmospheres, as is again to be expected; but this differential effect is less noticeable in the wethers, whose thermo-regulatory powers are superior to those of the hen and the sow.

In the case of the pulse rate, the increase brought about by high feeding rates is little, if any, greater in the hot atmospheres.

TABLE 4. EFFECT OF PROTEIN PERCENTAGE IN DIET UPON AVERAGE REACTIONS TO A HOT ATMOSPHERE. (D.B. 106° F., A.H. 8.3 grs./c.ft.)

Reaction studied	Animal	Protein percentage				
		5	11	17	22	28.5
Rectal Temp., ° F.	Australorp hen	108.9	109.9	108.6	111.7	111.3
	Wh. Leghorn hen	107.7	108.5	108.0	108.1	108.5
	Dog	101.3	101.7	102.2	101.4	101.1
	Wether	103.1	102.6	103.4	102.5	102.7
	Sow	104.0	103.9	103.3	103.9	103.5
Pulse rate, per per minute	Australorp hen	263	274	278	272	270
	Wh. Leghorn hen	260	269	271	272	269
	Dog	114	107	115	110	112
	Wether	60	54	73	58	56
	Sow	102	111	132	142	129
Respiratory rate, per minute	Australorp hen	85	102	94	129	100
	Wh. Leghorn hen	62	112	89	125	100
	Dog	209	228	226	227	233
	Wether	140	150	189	148	142
	Sow	125	158	131	180	132

The hot-dry atmosphere employed in these studies results in a greater accentuation of the increments induced by feeding than does the hot-wet atmosphere with hens, but not with sows or wethers.

The further increment of rectal temperature produced under hot conditions by high feeding rates may be of great importance to animals with relatively poor thermal regulation, such as hens and pigs, but not of much consequence to animals like the sheep whose thermo-regulatory powers are relatively good.

That the current rate of feeding is relatively more important than the body form resulting from past nutritional experience is suggested by the rapidity with which the differential responses of hens and wethers to temperature were reversed when the diets were reversed.

These findings suggest that, in the case of animals which do not sweat freely, it would be good husbandry practice if heavy or fat animals are required, to push their feeding during the greater part of the year, but to slacken the rate of feeding during the hottest part of the year in order to minimize untoward heat effects. With hens, this would apply more to hot-dry climates than to the humid regions, but for sows, it would apply to both areas.

A comparison between the effects of high-plane feeding and hot conditions, applied separately and together, brings out certain aspects of the rela-

tive roles played by the cardio-vascular and respiratory systems in metabolic processes in different animals. This will be discussed elsewhere, in connection with the general problem of comparative heat regulation.

Effects of Protein Proportions in Iso-Caloric Diets

General Plan of Experiment

Four of each of the two breeds of hens, a dog, a sow and a wether were fed for a week on each of five rations in succession, and exposed to a critically hot atmosphere (D.B. 106° F., W.B. 82° F., A.H. 8.3 grs./c. ft.) on the last day of each week. Three basic food mixtures were made as follows:

	Mixtures		
	A	*B*	*C*
Rice starch	90	—	—
Lucerne meal	10	10	10
Maize meal	—	45	30
Wheat meal	—	45	30
Meat meal (65% protein)	—	—	30
Mineral supplement	3	3	3

From these the five rations were compounded as follows:

Food Mixture	*Ration*				
	I	*II*	*III*	*IV*	*V*
A	50	—	—	—	—
B	50	100	67	33	—
C	—	—	33	67	100
Protein %	5	11	17	22	28.5

The calorific value of the ration amounted to 1600 gram-calories per lb. To the pig and the sheep 3 lb. per day were given, and to the dog, 1 lb. per day. The hens were given the food at night and allowed to eat next morning until their entry into the room at approximately 9:00 A.M. The other animals were given their food a half to one hour before entry. The dog did not eat with relish, even when the meal was made into biscuits and lightly cooked, but the other animals ate readily.

No food was given during the test, but adequate water was provided.

Results and Discussion

From table 4 it will be seen that the high average values of rectal temperature, pulse rate and respiratory rate, characteristic of exposure to the hot atmosphere used, were not consistently affected by the percentage of protein in the diet.

The experiments have not been repeated with larger numbers of animals because a similar lack of effect had been found previously when human subjects were being studied, and this lack of effect on men has since been confirmed by Pitts *et al.* (1944) at the Harvard Fatigue Laboratory. A survey of the literature has yielded only one report of a high-protein diet affecting the reactions of an animal to heat. Giaja and Males (1927) reported that a duck fasting, or fed on a carbohydrate-rich diet, showed "dyspnoea" when the surrounding temperature reached 28–30° C., whereas when it was fed on a protein diet, dyspnoea occurred at 24° C. The time at which panting occurred in our pig, whether in relation to the time of feeding or the time of entry into the hot room, was not affected, however, by the percentage of protein in the diet.

The practical point arising from these studies is that any fear that a high proportion of protein in the diet (as distinct from a high caloric diet) will place the animal at a disadvantage in hot weather, may be dismissed.

The important fundamental question arises, however, as to the relationship of the specific dynamic action of nutrients to heat regulation. If an animal is exposed to an atmosphere in which it has great difficulty in maintaining its thermal balance, then the addition of any metabolic increment should adversely affect the animal's reactions. We have seen that a high rate of feeding does this. But we are now faced with the fact that protein intake which, at least in carnivores, is generally regarded as giving rise to an increased heat production of 30–40 percent of its net caloric value during the next few hours, does not adversely affect the reactions of men, hens, dogs, pigs or sheep to critically high temperatures, at least under quiet but not basal conditions. In fact, in one trial the pig showed less reaction when fed just before entry to the hot room than when food was removed the preceding night.

Forbes and Swift (1944) are of the opinion that the concept of specific dynamic action, as developed from considerations of simple nutrients, needs modification when mixed diets are fed. The results here reported are in accordance with their demonstration "that it was the metabolizable energy, and not the protein content of these diets, which dominated the production of heat".

On the other hand, these and other observations made in the course of our heat studies, lead us to the opinion that the relationship between heat production as part of activity above the basal level on the one hand, and heat production in the course of intermediate metabolic processes on the other needs careful re-investigation where the animal organism is threatened with a breakdown in the heat balance in the direction of hyperthermia. Simple

algebraic summation of known isolates certainly seems to be impossible. It seems worth considering the concept of a "heat pool" as a homeothermic device under these rather extreme conditions, to which the contributions from some sources may be restricted when those from others are augmented.

Summary

It is often desired to raise heavy or fat animals in hot climates but conflicting ideas are held as to whether heavy feeding renders them unsuitable for tropical and sub-tropical conditions.

Experiments were carried out with White Leghorn hens, Australorp hens, Middle White sows and cross-bred Border Leicester-Merino ewes, in which some animals of each kind were reared upon a high-plane diet and some upon a low-plane diet. Once a week each animal was exposed to a hot atmosphere for seven hours. Hot-wet and hot-dry atmospheres were used on alternate weeks. The behavior of the rectal temperature, pulse rate, respiratory rate and weight loss was measured.

It was found that, in all animals studied, the reactions of the high-plane animals to hot conditions were significantly higher than those of the low-plane animals. This was much more pronounced under the hot-dry conditions. When, after several weeks, the diets of hens and ewes were reversed, the relative reactions of the two groups upon exposure to heat were reversed much more rapidly than the body weights.

In another series of experiments, animals were fed successively upon different diets which were of equal caloric value but contained proportions of protein varying from 5 to 28.5 percent. Hens, a dog, a ewe and a sow were used. After a week's feeding with a particular diet, the animals were exposed to a critically hot atmosphere for seven hours and the reactions studied. In no case was any evidence obtained that a high proportion of protein had any significant effect upon the reactions of the animals to heat.

It is concluded that the caloric value of the current diet has a significant, and at times practically important, effect upon the reactions of animals to hot conditions, but the proportion of protein contained in the diet is of no significant moment.

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ANIMAL HUSBANDRY IN THE CARIBBEAN AREA[1]

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LIVESTOCK and poultry, first brought into the area by the early conquerors, are as much a part of the picture as the people who inhabit the region. Today, however, it is evident that probably within the last century certain crosses of breeds from Europe and North America have been made in all animal classes, though many examples of undiluted *criollo* stock still can be found. In some places, also, introductions have been maintained in their purity, and are doing well. For the most part, however, the production and quality of animals and animal products is well below what it could be, with the result that the average per capita consumption of all animal products is considerably less than what would be regarded desirable in a good diet.

Factors Affecting Livestock Production

The Caribbean area, by its subtropical and tropical situation, would appear to be ideal for animal production. However, to those who are acquainted with the region, the problems are as great or even greater than in the temperate zone, and, with altitude, even in the tropics one may find some of the severe winter conditions of the north. For the most part, one finds two rather sharp seasons—the rainy, when all plant growth is most rapid, and the long dry period of little or no growth. Quantity feed problems do not exist during the times when rains are abundant. It is when they stop that severe problems of maintenance are encountered, and which for the most part remain unsolved except for those fortunate few who can irrigate, move their animals, or have made provision for some form of feed storage.

The problems of climate that have been met by the indigenous livestock population over a period of more than 400 years are those of being able to withstand an amount of annual rainfall as high as 200 inches or more; to survive a dry season of little feed during a seven months period in some instances; and to endure the humidity, and the high midday temperature conditions so common throughout the entire area. Fortunately, the nights offer relief from the sometimes oppressive daytime conditions during which livestock as well as people frequently take a *siesta*. These are the climatic conditions that must be met by all classes of introduced stock, and their ability in so doing can be measured from utter failure, to outstanding success where intelligent effort has been applied to the problem.

[1] Presented as part of a symposium on "A World-Wide View of Animal Husbandry" at the opening session of the annual meeting of the American Society of Animal Production in Chicago, on November 29, 1946.

Though infrequently stressed, good animal production is dependent upon the soil because it contains those mineral elements that the plant takes up and from which the animal makes bone, muscle, and the animal products used by man. The heavy prolonged rainfall areas are low in those soluble minerals so necessary to a good frame in cattle and horses. In these regions, even in those parts underlaid with limestone, the animals may be smaller than what one would expect. Bone and blood studies are needed definitely to establish whether such size is due to a mineral lack or is due to the character of the animal itself. However, in places of lesser rainfall, it has been observed that the larger animals come from areas of limestone soil. The Caribbean slope of the continent, for the most part, lacks the recent volcanic eruptive material so common to the Pacific slope of these countries, where the soils are much deeper and richer in plant food (Hardy, 1945; Pendleton, 1945). There are certain Caribbean Islands, volcanic peaks, that are fortunate in having similarly rich soils. From the standpoint of production, such soils, except for certain lowland areas, are usually given over to crops, so that animals are found where cropping is a problem. Though careful critical chemical studies have not been made, evidences of the effect or of the lack of some minerals have been observed. These include goiter, even in lands exposed to sea-borne winds that might carry Iodine in the spray. Though the salt commonly used may be made from the sea water, it is usually not given to animals and is even difficult for people to obtain. Bighead has been observed in horses, more frequently in those graded up to Morgan and Thoroughbred blood. Lacking definite evidence, it is believed that the faster growth and increased size of such animals have created nutritional problems not so apparent in the smaller *criollo* stock. Squibb (1945) apparently corrected this bighead problem through ration changes and shark liver oil therapy. Because the latter has introduced a new factor, the El Salvador Experiment Station is contemplating further study under Dr. Mario Lewy van Severen, head of the chemistry department.

Similarly, in the sheep areas, the introduction of large type rams and grading up to purity thereto, has created problems, one as yet unsolved, wherein following years of heavy prolonged rainfall with the resulting rapid lush forage growth, as high as 40 percent or more of the lamb crop may die following weaning at the beginning of the dry season. Death seems to be due to an anemia as no blood is in the veins but a yellowish exudate is invariably found in the abdomen. Could this be a form of cobalt deficiency?

Transportation is one of the biggest problems throughout the area. Rivers, when navigable, serve for transportation purposes. Paved roads are few, but are increasing, as also are gravelled and other all-weather highways, particularly in Central America and Colombia. However, during most of the

rainy season, travel is much restricted except by airplane. In fact, the airplane may be the solution to many of the problems in the field. Cattle walking six days from the Colombian *llanos* to Bogotá lose weight and much needed fat. To avoid this, a modern packing plant will be erected on the edge of the *llanos*, and carcasses flown to Bogotá.

Regardless of all other factors, the fundamental problem is one of feed and nutrition in general. This in itself, with good care and management, could easily effect 40–50 percent improvement. Except in a few dairies throughout the area, and with blooded horses, there is no feeding of animals such as we in the United States know it. Corn, so common here as a stock food, in the continental Caribbean area is a human food, so that when given to animals, it literally is taken from the mouths of babes. The important protein by-products either are lacking or only available in small quantities, thus making desirable rations difficult to compound, and when made, expensive. Therefore, a constant search is being made for corn substitutes such as dried coffee pulp which has been successfully fed to dairy cows in El Salvador and Guatemala (Work *et al.*, 1946). The production of yeast from cane molasses to serve as a source of protein is already under way in some of the British Caribbean possessions.

Silos, so common in the United States, are most widely in evidence in Nicaragua. Corn, sugar cane, and sorghums are used in this manner. Some hay is made under difficulties, and so is expensive. It is usually of Pará or molasses grass and not of the best quality.

In the Guatemala highlands, dairy cows receive green alfalfa produced from plants, the original seeds of which came from Spain over 400 years ago. Here, records as high as 10,000 kilos have been observed in one group of well fed Carnation-bred Holsteins. The feeding of other fresh cut green material is also practiced, but introduces many problems (Patterson, 1941).

Because of feed supply problems, feedlot ventures, with beef cattle and hogs, and commercial poultry production, are not feasible nor profitable due to the high cost of feed and the low selling price of the resulting product. Only with dairy cattle is such feeding profitable, largely because the selling price of the milk is high and so denied to the large part of the potential consumers.

Livestock and Their Production

Though there are many cattle, in general there is neither a beef industry nor a dairy industry as such. Until such differentiation for purpose is made, progress will be difficult. However, in most countries desirable groups of each may be seen. Costa Rica, for example, is famous for its fine dairy cattle, Guernseys and Jerseys particularly, though there are some Brown Swiss,

Ayrshires, and Holsteins. And some of you may have seen the fine herds in Cuba. Colombia, too, has fine Holsteins, Ayrshires, Shorthorns, and Red Polls. Here, a new "breed," the "Romo-Sinuano" has developed in the Sinu Valley. It is a polled, light to dark fawn color animal, well able to withstand the lowland conditions.

Meat and dairy products may be produced from the same type of animal, and frequently these animals may be in the same herd. Beef usually comes from 5–7 year old animals of indiscriminate sex, though in some places grass fattened 3-year olds are marketed. Castrations, except in well managed units, are delayed until between 1 and 2 years of age and the lack of wire, and its expense, (barb wire in Guatemala sells for as high as $15 a 90-lb. roll) work against smaller pastures and the early separation of sexes. Uncorrected milk records of 1500 to 3000 pounds per year have been obtained from varying colors of *criollo* cows in the foundation herd of the Escuela Agricola Panamericana at Zamorano, Honduras. Their first calf daughters, sired by purebred Guernsey, Jersey, or Holstein bulls, are just coming into production. Under the same conditions of feeding and management, they are exceeding their dams by from 1000 to 2000 pounds per year. However, Harrison (1944) and Howe (1946) have reported difficulty in maintaining fertility and production through successive pure generations of Temperate Zone cattle. Marked improvement resulted through crossing with Zebu types of cattle. Our own observations have shown us that with good systems of care and management, the use of Brown Swiss bulls on native cows is giving excellent results in some coastal areas that have a long dry season. Black's (1939) experience in Venezuela is similar. This indicates that in any improvement program, the value of the contribution to be made by the indigenous cattle population should be given every consideration.

Though Zebu blood has increased the size of the lowland cattle, the type of horse to handle these larger cattle, in general, has not changed. These horses, except where improved blood has been introduced, seldom exceed 14 hands, are fine boned, rather narrow chested, with rather straight backs, but frequently with steep croups. The muscling is good and the animals are sturdy, frequently possessed of tremendous endurance as measured by long hours under the saddle in the deep mud of the rainy season. Horses, mules, and burros are most frequently used as saddle and pack animals, though the introduction of draft blood in Colombia is resulting in the use of horses singly or in teams to draw loads on 4-wheeled wagons. However, Berliner (1946) reports fertility problems in Percheron stallions imported into highland Colombia.

Swine production is usually on the basis of 1 and 2 sows in the hands of the small rural householder. Hogs are important throughout the entire Carib-

bean area more because of the lard produced therefrom than from a meat standpoint, because fats and oils are an important part of the diet of the people. As much fat as possible is removed from all meats before it is placed for sale in the public markets. Hogs must have good legs in Caribbean countries because most frequently they walk to market. Distances up to 200 kilometers may be covered in this way. Perhaps this may account for the smaller light weight animals, as the very heavy hogs lose much weight and frequently do not stand up under such treatment. Just what might constitute a *criollo* type of swine is not known. From observations and deductions, the common hog must have been a multicolored chuffy beast, that may reach mature weight at 100–150 lbs. The muscling is inferior and hams made from such animals are small and flat, and the bacon has very little lean. Remarkable improvement occurs where boars of some of our hog breeds have been used.

Except in the highlands, sheep are unimportant. Basically, they are similar to our own Navajo sheep. In the hands of the Indians they remain so, but crosses of improved breeds, Rambouillet, Hampshire, and others have been made. Though good fleeces may be found, most common are those containing a mixture of wool and hair. Yolk is lower than in U. S. fleeces, and clips in Guatemala, for instance, rarely exceed a kilo. Sheep may be sheared twice a year because by so doing wool loss is prevented. Throughout the area the value of this species lies in the manure they produce, but especially so on the coffee *fincas*, where they may be corralled or sheltered during up to 14 hours of the day, and also during rainy hours.

Eggs and poultry products, more frequently than not, come from fowl of the game type, and eggs are dear. Egg production is estimated at 50–75 per hen per year. Some improved flocks have been observed (Reds, White Rocks, and others), where egg production is 150 per bird or better. Turkeys are abundant and cheap though the birds are not large as a rule. The Muscovy duck is common in Central America as this region is its native home. Like swine, poultry may be considered a household venture, as flocks are small. Some commercial ventures are beginning to appear, however.

Diseases and parasites are two factors that place a severe handicap on economic livestock production. Studies made by the Pan American Sanitary Bureau (1945) indicate a low incidence of tuberculosis and Bang's disease among *criollo* cattle, but a higher incidence among cattle with more improved blood. Anthrax, blackleg, "flu", poxes, cholera, navel disease and many others, annually account for losses that have not been estimated but must run into the millions. In cattle, for instance, except in carefully managed herds, calfhood loss due to diseases and parasites may run to over 50 percent. Just recently, Guatemala has had a most severe outbreak of hog cholera. Some countries are producing their own biologics, but many thou-

sands of doses of American biologics are frequently used to control these diseases. However, in general, due to a lack of sufficient veterinarians, there are no disease control programs except in Cuba and Colombia, both possessing good veterinary schools. Fortunately, in no part of the Caribbean area does the dreaded hoof and mouth disease exist,[2] and so from the standpoint of our own industry, the region constitutes a protective zone. The Congress has appreciated this fact by passing the Swan Island Animal Quarantine measure providing for international use of the station, in this manner avoiding the chance of introducing into the region serious diseases whose later entrance into the United States no law could prevent. All of the Central American countries have expressed their interest and intent to use these facilities once they are available.

Parasites are many and some of them equally as destructive as diseases. The cattle tick, carrier of piroplasmosis and anaplasmosis, is the one that most frequently takes its toll of imported animals. The *Dermatobia hominis* warble (so called *nuche* or *torselo*) annually almost completely ruins many hides in Nicaragua, Costa Rica, and Colombia. Multiply our ox warble to cover the whole body and you have something of a picture of the *nuche*. The trypanosomes are evident in Venezuela, Colombia, Panama, and elsewhere, as are other blood parasites.

Internal parasites are common but except in confined areas, the known loss due thereto is not so high. These include tapeworm, trichaena, liver flukes, and many forms of intestinal parasites. Climatic conditions frequently are ideal for the development of these pests and where good management is lacking may make control difficult. However, there is much evidence (Lucker, 1941) that points to the value of heavy rains, dry weather, and intense sunlight, as factors in parasite control. Only when intensive systems of management are engaged in, does parasitism become evident as taking its toll.

There are many intelligent animal men in the Caribbean area and where these gentlemen are operating, applying their knowledge and reasonable management and care, progress is being made. Many of them are students of our U. S. agricultural colleges or are widely read and keenly aware of the needs and problems. It is in the herds and flocks of these people that one finds the 20,000 pound dairy cows, the fine horses, and beef cattle as good as anywhere in the world. But on the whole, in spite of the many adverse environmental conditions, above all is the human element that contributes so much to care and management (Black, 1939; Dahlberg & Hodgson, 1943; Hodgson & Hunziker, 1942, 1943; Work & Smith, 1946). This is largely due

[2] Except for the recent outbreak in Mexico, which country incidentally is not generally considered as a part of the Caribbean area.

to the lack of herdsmen who can apply intelligently the directions of the owner and even use their own judgment. Those who have been able to make progress have done so because they themselves are operating owners, or because the people they employ have the needed "know how." It is these latter instances that show what can be done in the area, but it will be many years before such a condition becomes general.

Significance of the Livestock Industry in the Caribbean Area

What does all this mean to the stockmen of our country? The following points have impressed themselves: The industry in the Caribbean area, independently, has developed to its present extent due in a large measure to the many sales made by U. S. breeders into the region. For instance, the Government of Venezuela recently purchased in this country over $1,000,000 worth of grade and purebred livestock of various classes to upgrade the local animals. In November, 1946, 1000 head of sheep were flown from San Angelo, Texas to Guatemala, 250 in a plane, at an initial purchase price of $25,000. It seems wise that our breeders continue such sales because this gets into big business. If our people do not sell, there are others who are most anxious to enter this hungry market (and are, to a certain extent). And because these people are our neighbors, we should be interested in their well being. What affects them will sooner or later affect us. Thus, the importance of all of us cooperating in keeping out of the area serious endemic diseases that know no law but to spread is evident.

From the standpoint of possible competition from the area, possibly it can best be summed up in the words of a prominent U. S. rancher, when he was asked this question. He stated: "We need fear no competition for 100 years and I'll be dead then." When it is realized that the per capita consumption of milk equivalent is only about ½ pint per day, according to Hodgson and associates (1942, 1943), and that beef consumption, even in a cattle country such as Nicaragua, is less than 30 pounds per capita per year according to our own estimates and studies (1946), the statement made by this rancher becomes even more evident as the truth.

The development of the animal industry in the Caribbean is proceeding and will continue to do so. More young men are thinking of U. S. agricultural schools as training grounds. This makes for good will and mutual understanding. As the industry develops, its needs must be fulfilled. Most of the countries are looking to the U. S. to supply these needs—tools, machinery, biologics, and breeding animals. Sales of such create jobs in our own country and thus increase demands for the products of U. S. farmers. Let us get this business.

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ANIMAL HUSBANDRY IN CHINA AND INDIA[1]

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THERE are several reasons why our thoughts turn to livestock affairs in other parts of the world. First, there is the inquiring mind of the scientists, always seeking well-rounded knowledge of a subject. Even now, our knowledge of animal types and husbandry in some parts of the world is very limited. Second, there is our desire to take advantage of any superior types that might be useful to us, particularly in some of our less favorable environments. The use of zebu cattle in our subtropical regions is an example of this, and the possibilities along this line are far from exhausted. Finally, there is our interest in that multitude of problems that must be solved if the people of the world are to have an adequate diet and ample clothing. There is no need of recounting the importance of livestock in providing meat, milk, skins and fibers for those purposes. Some well-meaning persons have told us, in recent years, that the people of the world, and particularly of the United States, are to become more dependent on cereals and will necessarily consume less meat. So long as populations continue to grow, food must be had for them. So it is possible that a larger portion of the world's supply of grain may have to be used for human consumption and less for livestock. But it must be remembered that only a relatively small portion of the earth's surface is cultivated. Of the remainder, some is entirely unfit for food production and a little can yet be brought under the plow, but *the major portion that is useful in food production is land from which only livestock can harvest a crop.* Our own extensive grasslands are utilized rather fully, but similar vast areas in the world are making little contribution to the world's food supply, other than by the maintenance of small nomadic and semi-nomadic populations.

When our thoughts turn to China and India, no doubt many of us think of rice-eating millions and wonder about the importance of livestock in these countries. Using figures for about 1940, and making due allowance for the inadequacy of some of the statistics, we can obtain a rough approximation of livestock numbers, expressed as the numbers per 100 such animals in the United States.

China, on this basis, has 60 horses and 105 mules. We have so few jackstock that they are not listed in our statistics, but China has over 9.5 million donkeys and jackstock. These, combined with the horses and mules, bring

[1] Presented as part of a symposium on "A World-Wide View of Animal Husbandry" at the opening session of the annual meeting of the American Society of Animal Production in Chicago, on November 29, 1946.

China's estimated total equines to 140, in comparison to 100 here. For cattle, the figure is 35. Add to this approximately 11.5 million water buffaloes, and the bovine population is 50 compared with 100 in the United States. Also, there are large yak and yak-cattle hybrid populations on the Tibetan plateau and the southern edge of the Mongolian plateau for which no figures are available. China has 35 sheep, 505 goats, and 125 swine per 100 here. China also has many camels. There are about 100,000 in Ningsia and the Manchurian provinces, but no figures are available for other provinces where camels are used. Outer Mongolia has not been included in any of the above comparisons. The land area of China, exclusive of Outer Mongolia, is about 125 percent of that of the United States.

India has only about 53 percent of our land area. Her equine population includes 25 horses and 2 mules per 100 here, and somewhat over two million donkeys, bringing the proportion of equines to 30. In cattle, India exceeds us with 225. There are also 45 million water buffaloes, so that the total bovine population is over 200 million, or about 290 animals per 100 in the United States. Proportions for sheep are 90, and for goats 1400. Swine are of little importance, the proportion being less than 4 per 100 here. There are also about 1.1 million dromedaries or one-humped, camels and there are some yaks and yak-cattle hybrids in the Himalayan foothills.

These figures indicate the obvious importance of livestock in the agricultural economies of both China and India. How do these animals fit into the scheme of things on the farms and in the grasslands?

The place of livestock in any country is related intimately to the mode of living of the people. Mode of living is in turn closely associated with geographic and climatic conditions, and with pressure of populations. In China, there is a wide variety of conditions, and there are two main modes of living among the rural populations, characterized by the settled farmers of the eastern and southeastern parts of the country, and the nomadic and semi-nomadic peoples of the northern, western, and northwestern portions. There are also variations in racial stocks which affect the utilization of animals.

China is primarily a land of mountains. Level land is found only along some river valleys, in delta regions and in a few other areas. I have mentioned that the settled farmers live in the eastern and southeastern parts of the country. This area of intensive farming is divided into two main regions, the rice region south of the Chingling Mountains, and the wheat region north of these mountains. Millet and kaoliang are also important grain crops in portions of the so-called wheat region. In both the rice region, where much of the tilled land is flooded, and in the dry wheat region, terraced hillsides are the rule. In both areas, farms are small, averaging a little over 3 acres in the rice region and about 5.5 acres in the wheat region. In both areas,

the average farm is broken into about 5.6 parcels of land. Everywhere in the farming regions there is an oversupply of people and an undersupply of land, so that every available plot of soil is pressed into use for the production of human food. Under these conditions, livestock serve chiefly as work animals and scavengers, and as users of the few available by-products. Even so, a large livestock population is maintained.

The farming regions are occupied chiefly by people of Chinese racial stock. The farmers in the south use the water buffalo as the chief draft animal in rice fields. Cattle, small native ponies and some donkeys are used for packing and for draft on mountain farms where rice cannot be raised. Few sheep are raised in the rice region, except in remote mountain areas. Goats are found everywhere and provide meat and hides. Little milk is used by Chinese, either from goats, or from cattle and water buffaloes. Pork is the favorite meat, even though the average Chinese gets little of it. The richer farmers keep breeding sows, and pigs are raised by as many farmers as can afford to buy them and can find enough feed. They are kept chiefly as scavengers, turning vegetable refuse into manure for the fields, until 12 to 18 months of age or older. They are then fattened rather quickly by the well-to-do farmers who have surplus grain or by sugar factories and distilleries where by-products are available.

Owing to lack of refrigeration, pork and other meats must be sold within a short time after slaughter. The common practice is to begin slaughtering about midnight, so that meat will be in the open-air retail markets by daybreak the following morning. Bristles have been one of the important by-products of Chinese pigs, but the rapid development of synthetic bristles probably will reduce their importance. Next to pork, goat meat is most important in the Chinese diet. Some beef is eaten, mostly from worn-out cattle and water buffaloes. But there is considerable prejudice against eating the meat of a beast that has served faithfully in the fields for most of its life.

There are practically no water buffaloes in the wheat region, north of the Chingling Mountains. Packing and draft work on farms is performed by cattle, horses, donkeys and mules. Horses and mules are used for draft on highways, where highways exist. Horses in this region are of the Mongolian type, much larger than ponies of the South, but still only 12 to 14 hands high. Excellent mules are produced by mating such mares to the jacks of similar height from Shensi and Shansi. Swine in the wheat region are longer and less rotund, and are generally solid black, in contrast with the fatter animals, often with white markings, in the rice region. Sheep are more important in the wheat region, where there is considerable suitable grazing land. The goat is ubiquitous in China.

Chinese farmers have penetrated into the edges of the adjacent grass-

lands, wherever tillable land could be found, using land that should be reserved for producing winter feed for range livestock. But they are tillers of the soil, not animal husbandmen. So the management of livestock on the grasslands has been left to people of other racial stocks; Tibetans in the Tibetan Plateau, Mongols in the grasslands of the North, and Kazakhs and other groups in the Northwest. Mohammedans constitute an important group in northwestern Kansu, parts of Chinghai and Ningsia, and Sinkiang. They are not a distinct racial group but include Turkish, Mongolian and Arab stock, mixed with Chinese, as well as some Kazakhs and others that adhere to this religion. Naturally, there is little interest in pork production in this region, quite apart from the fact that there is little suitable feed.

Sheep provide the foundation for existence in most of the grassland areas. Mutton is the most important meat. Wool is made into clothing, blankets, rugs and felt. The felt is used for boots and to cover the movable yurts in which many Mongolians and some others live. Pelts of young sheep are used to line gowns to give protection from cold winter winds. Some skins are made into leather. Inflated sheepskins are bound together to make rafts that are used on Yellow River. Droppings are collected at night in corrals and used as fertilizer and fuel. Some sheep milk is used as human food. Wool is sold, going chiefly, in prewar days, into the carpet wool supply of the United States, to obtain cash for purchase of the few manufactured articles used in the simple life of the nomad.

In the Tibetan grasslands, yaks vie with sheep for first place in economic importance. They are used for milk production and as pack animals, and to a limited extent for riding and draft purposes. Their long hair is used for making cloth for tents, and the finer undercoat is used in other fabrics. Animals are herded on the high mountains during the late spring, summer, and early fall, and are kept in the valleys in winter. During the good grazing season, butter and dried casein are prepared and stored for winter use. These and barley flour are major items in the winter diet of the Tibetan. Rancid butter is mixed with tea to make the favorite beverage. It is also used as cold cream to give protection from the wind, as "clay" for extensive sculpturing for religious ceremonies, and as fuel in the candle pots of the lamasaries. Hybrids between yaks and cattle are also produced, and are larger, stronger pack animals and better milk producers than yaks, but they do not have the stamina and ability to exist under very rigorous conditions that are possessed by the yak. Yaks and yak-cattle hybrids are also important among the Mongols in the higher regions of Kansu and Inner Mongolia.

Cattle are also found throughout the grassland area, except at the higher elevations where only the yak can thrive. They are mostly of the Mongolian type and produce somewhat more milk than the cattle in the Chinese

farming regions. Even so, two quarts is a good daily production, if one leaves enough to keep the calf alive as a necessary stimulant to letting down of the milk at each milking.

Few donkeys are found in the open grasslands. Here, Mongolian horses provide the chief means of transportation, other than that provided by yaks in the uplands and by camels in the lower, drier areas. The camel is used chiefly in the winter. Herds of these animals are taken to the uplands for grazing during the summer, so that their humps fatten and stand erect, providing stored food to help them through the lean winter days of caravan duty. Animals as yet have no real competition in the carrying of freight in upland Asia. In the farming regions, the only real competition is provided by man himself, and by small boats propelled by man on the inland waterways.

India and China have had little interchange of stock and ideas in their development. The natural barrier provided by the Himalayas and their extension to the south in Burma, popularly known as "The Hump," have prevented any such interchange, yet there are many similarities. Both countries are characterized by over-population and the resulting problem of inadequately small farms. The majority of the people in the farming regions of both countries are dependent upon a cereal diet. In India, 75 percent of the cultivated land is devoted to cereals, principally rice and wheat. Both countries have considerable areas devoted to grassland production of livestock. In India, these regions are chiefly in the drier portion of the northwest, and in the low mountain country in the south. As in China, there are racial differences which have their effects on livestock utilization, such as the Hindu's reverence for the cow, and the Moslem's abhorrence of pork.

The whole structure of Indian agriculture is based upon the use of bullocks and other cattle for draft purposes. Cattle also furnish much of the power for highway transportation in rural areas, and a considerable amount even in large cities. Most native breeds are used solely for draft, but some types, such as the Sahiwal, Red Sindhi and Gir produce fair amounts of milk. In animals of the latter breeds, milk yields of four to five thousand pounds per lactation are rather common, and under the best of conditions, yields of ten thousand pounds or more are sometimes obtained. The majority of the people are Hindus and eat no meat, hence milk and milk products provide most of the animal protein. The average Indian rice-eater's diet is inadequate, in comparison with the optimum requirements laid down by our National Research Council. For several important constituents, the rice-eater consumes the following amounts, expressed in percent of the optimum: Calories, 58; Total protein, 54; Animal protein, 3; Calcium, 20; Iron, 75; Vitamin A, 10; Vitamin B_1, 27; Vitamin C, 20. Obviously, livestock

make little contribution to this diet, other than to provide the power for tilling the fields upon which the food is raised. In areas where cattle breeding is an important pursuit, the milk consumption including ghee, or clarified butter, curd and other milk products is higher, averaging about ten ounces per person daily, according to results of one survey.

With her huge cattle population, India has a host of problems, including how to reduce numbers of bullocks to those actually needed for work, how to overcome opposition to castration of scrub bulls in villages where improved bulls are placed, how to eliminate wasteful maintenance of thousands of diseased, crippled and otherwise useless cattle in ping-rapoles or old-cattle homes, how to salvage the thousands of good cows and water buffaloes that are shipped into city dairies, milked to the end of a lactation and slaughtered, how to find a substitute fuel so manure can go on the land instead of being burned, to mention a few.

The water buffalo is the chief milk producer in India. Herds of animals of the Murrah and related breeds of the plains of north central India often produce about four thousand pounds of milk, with about 7.5 percent fat, per lactation.

The numbers of horses, mules and donkeys already given indicate the small importance of these types. Horses and ponies are of most importance in the grassland regions of the northwest and in the Himalayan foothills. The donkey and mule are generally held in low regard. Camels (dromedaries) are used extensively for packing in the northwestern portions of the country, and to some extent for draft also, around cities like New Delhi.

Goats are found in all parts of India. They vary in size from the miniature animals of Bengal to the large Jumna Pari breed of north central India. Many are milked but little has been done to improve milk-producing qualities. They provide meat for the Moslem and other flesh-eating portions of the population, and also skins for leather. Long-haired types in the Kashmir area provide some fiber for textiles.

Several types of sheep are produced in the drier areas adapted to sheep production. These include the fat-tailed sheep with very coarse wool in the northwestern regions adjacent to Afghanistan, and thin-tailed types that produce wool of somewhat better quality, in other portions of northern and northwestern India and in some sections of southern India. There is also a brown hair sheep in southern India that is used for meat and skin production. Some sheep are milked and ewes of the Lohi breed are reported to give as much as eight pounds daily at the peak of lactation. The milk is rich in fat, and some is mixed with milk from cows and buffaloes for making ghee.

Swine are of little importance. In villages where they are raised, they serve

chiefly as scavengers, often living to a considerable extent on human feces. There was a temporary boom in pork production during the war, owing to the presence of many foreign troops in the country.

Close economic ties exist between our western grasslands, the mid-western feeding areas, and the meat-consuming population centers in the East. Such economic ties have not been developed in China and only to a limited extent in India. In China, there are movements of working animals from the mountain grasslands to the farms in lower areas within the farming regions, of Mongolian horses from the grasslands into the wheat-farming region, and limited amounts of wool and hides find their way from the grasslands into commerce, but in general, the farming and pastoral economies are as distinct as in the days when a Great Wall was built to keep them apart. In India, working bullocks move from the grazing areas of Baluchistan, Northwest Frontier Provinces and the Punjab to the farming areas in the north central plains; buffalo and zebu cows move from country districts into city dairies; wool and hides move from the grazing areas into trade channels, but there is not the fullest development of economic ties between the pastoral and farming economies. Neither is there the large demand for livestock products among the Hindu population that is necessary to development of close economic ties.

Obviously, this is only a glimpse at the immense animal industry of either country. Much could be said of the many varied breeds and types of livestock that are found in China and India. But that could not be adequately done without including many pictures, and such descriptions have already been given in several publications issued during recent years on Chinese and Indian livestock (see Literature Cited). But there is one point that I wish to emphasize. If one examines the photographs in the publications mentioned, most of the types of animals found in both countries may appear quite unimproved. And they would be so under Corn Belt or other near-ideal conditions. But it must be remembered that rice straw is first-class roughage for livestock in the farming areas of both China and India, that animals must pull through the winter on very poor rations in the grassland areas where little feed is put aside for their use, and that under conditions there our improved breeds often could not survive, much less produce at satisfactory levels. Until economic conditions, education, and other factors make possible the better feeding and management of livestock in those countries, the first measure of performance is ability to survive, coupled with only as much productivity as the land will support.

Relatively few well-trained workers are available in either China or India to assume leadership in livestock and range and pasture improvement. This does not mean that they are without good men, for each country has a

handful of well-trained technical men working in various phases of animal industry. Most of the leaders have had advanced training in this country or Great Britain, and in neither place, with few exceptions, have they learned the all-important lesson of breeding animals adapted to the local environment. Too frequently, they have seen fat rams and bulls and sleek dairy animals kept under the best of conditions, and have as their main objective the transplanting of such animals to their native countries. The fallacy of such an approach, at least in many circumstances, is illustrated by the results of grading up with foreign dairy breeds, mostly Holstein, in tropical India. Records are available on animals having from $\frac{1}{8}$ to $\frac{7}{8}$ imported blood. The production trend begins with 4839 pounds in animals with $\frac{1}{8}$ imported blood, rises to about 6980 in the $\frac{1}{2}$ and $\frac{5}{8}$ groups, and drops to 6180 in animals with $\frac{7}{8}$ imported blood. These are animals that have been kept for the most part in military dairies and governmental experiment stations, and have had much better care than could be expected in native herds. Animal husbandry and all other agricultural education is also limited by the fact that most of the men who have sufficient wealth to attend college have never worked on the land or with livestock and so do not have a full appreciation of their own animal industry and its problems.

One final point. Do we have an interest in the improvement of livestock production in underdeveloped countries such as China and India? I believe we do. And the answer seems to me to be the same, whether we look at this problem strictly from the humanitarian side, or entirely from the selfish side of guarding and improving our own well-being and our position among the peoples of the world.

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ANIMAL HUSBANDRY IN GREAT BRITAIN[1]

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AN UNDERSTANDING of the livestock situation in Great Britain today can be gained only by some reference to the livestock situation prior to the war and a rather detailed reference to the general farming and cropping system followed in Great Britain before the war and the one being followed now. Great Britain is, in the main, a country of small diversified farms, with livestock as the main interest. Relatively few farms are livestock farms only, and hardly any at all specialize in only one kind of livestock. The average breeding establishment, that is well known in the United States as a producer of outstanding cattle or sheep, is usually a farm that has sheep in addition to the cattle that are so well known to us, or cattle are found on the sheep farms. Most of the rough feed for the livestock is produced on the farm, and before the war much of the grain was also produced there.

Prior to World War II, Great Britain was producing about 40 percent of the food she consumed. Much of the meat, animal products and wheat were imported, as were most of the fruits. Under normal conditions, I doubt that Great Britain would ever produce more than half of her food requirements. During the war and the year or two since the war, Great Britain has been producing about two-thirds of the food consumed. In order to accomplish this it was necessary that the farming and cropping systems be changed. More land was planted to vegetables and cereals and less to crops to be consumed by livestock. This was a logical change since much less shipping space was required to import meat products, dried milk and dried eggs than to import wheat or other cereals. Naturally, as it became necessary to use more cereals for human food, less were available for livestock. This situation was erroneously interpreted by some people in the United States who made the suggestion that we should go on a plant diet rather than an animal diet. They reasoned that it was a more economical way of using the crops and, further, that we could do it because it had been done in England and Scotland. I think that before we go further with the discussion of farming and livestock production today, we need to set these people right. It is true that certain livestock were decreased in number in order that more human food could be produced. I asked every person with whom I came in contact if this could have been done had they not had outside sources of animal products.

[1] Presented as part of a symposium on "A World-Wide View of Animal Husbandry," before the American Society of Animal Production in Chicago, Ill., on November 29, 1946.

They were unanimous in saying that they could not have survived in good health had they not had overseas countries to ship the food from animal sources to them. So, their plan was not to eliminate foods of animal sources, but to depend on foreign countries for those foods and increase their own production of the very necessary and more bulky cereals and vegetables. In other words, they were able to increase the production of food they consumed simply because they could depend on overseas countries for the necessary animal-protein food.

A quick look at the change in farming in England, particularly the cropping, is necessary in order to understand the livestock situation of today. In the United Kingdom the acreage of wheat (not good flour wheat) went from 1,766,000 to 3,230,000, or an increase of about 83 percent. Barley increased from a little over a million to just over two million acres, or an increase of 95 percent. The total grain crops increased from five million to nine million, or up 78 percent. Potatoes increased from 704,000 to 1,420,000, or an increase of 101 percent. Sugar beet production went up over one-fourth. The total arable land increased from about thirteen million to nineteen million, or an increase of 50 percent. These increases were brought about in two ways. One was by recovering marsh land by necessary drainage, but most of it was accomplished by plowing land that had previously been in pasture. I saw wheat growing on land that I was assured had not been plowed since the time of the Romans. I saw barley growing on hillsides in Scotland that had never been plowed until caterpillar tractors became available. The hillsides were so steep that they could not be plowed by horses, nor could they be plowed with the use of ordinary tractors. It is obvious that the cropping of this land was an emergency measure and that under normal conditions it would not be long continued. Many of the pastures on the chalk hills in Southern England where many of you have seen herds of cattle and flocks of sheep are now being cropped. This soil, as you know, is relatively thin and the soils men told me that regardless of how much fertilizer was applied the yields were now on the decrease and this land would have to be put back into pasture within one, two or three years in order to conserve it. So, the increase in crops and vegetables was attained at the expense of normal, accepted methods of farming.

I was to discuss livestock in Great Britain, but I am sure that with this background of information on wartime changes in cropping, it will be much easier to understand some of the changes in livestock numbers that naturally resulted. Incidentally, the increase in land being cropped took place in spite of the fact that approximately three million acres of land were used for airports, cantonments and various types of military installations, so we can see that there were not many acres of land in England that were not in use.

The greatest number of sheep were found on the chalk hills in Southern England and since many of these hills are now in grain crops, it is understandable that the sheep numbers decreased. This decrease amounted to approximately 25 percent. There was one other change that sheep men told me had taken place. The smaller breeds of sheep, both in purebred and commercial production, suffered during the war. The Britisher was, of necessity, more interested in pounds of mutton than he was in the quality of it. Consequently, some of the well established flocks of Southdowns have disappeared. I got the impression that on a percentage basis, the number of sheep of the larger breeds had definitely increased. I am not prepared to tell you what the future holds for sheep production in Great Britain, but I had the distinct impression that the flocks of pedigreed sheep that have been maintained were kept at a very high level of quality. Although there are fewer flocks of some breeds, those that are available contain animals of the same high class as were in them prior to the war.

Hogs and poultry, being the main consumers of grain, necessarily suffered the greatest decrease. The decrease in pigs from 1939 to 1945 was 57 percent. That meant that the numbers went from something over four million to a little over two million. We can readily see from these figures that the amount of pork products available to the population of Great Britain from their own production was very small. The human population is in the neighborhood of forty-six millions. Most of the pedigreed herds of pigs were maintained, but at reduced sizes. Selections of breeding stock were made at a very early age and the quality of the herds was very well maintained. Many of the large breeding establishments were dependent largely on garbage, this being hauled as much as 100 or 150 miles from ships docking at Bristol and other ports. This practice was blamed for one or two of the outbreaks of foot and mouth diseases that occurred during my few months in Britain.

Poultry numbers decreased about 25 percent, but this was not true with cattle. According to figures released by the Ministry of Agriculture there were 7 to 8 percent more cattle in the United Kingdom in 1945 than there were in 1939. This increase was largely in dairy cattle, since there was a real effort made to produce whole milk. However, the number of beef cattle was not decreased as greatly as some of us had been led to believe. I know of no herd being dispersed because of lack of feed. I know that there were quite a number of new pedigreed herds established during the war period. It was impossible to buy cake for beef cattle so they had to be maintained on pastures and grain grown on the farm. However, the farmer did not have the choice of feeding all the grain he grew. It was necessary that he deliver all millable grain to a licensed buyer. I am not quite sure of the figures, but at least it will do as an example to say that a farmer was required to deliver all

the wheat he produced on the farm to a licensed buyer except the screenings and tailings. In no instance could the screenings and tailings exceed 10 percent of the production. If, on inspection, certain grains were found to be unsuitable for human consumption, those grains could be fed on the farm. We in this country remember the government regulations that were aimed at decreasing the grain fed to beef cattle. This was accomplished by having very little spread in price between good cattle and choice and prime cattle. In other words, it became unprofitable to finish the cattle to a high degree. Therefore, most of our feeders marketed cattle when they were in condition to grade high good, or low choice. In Great Britain everything was bought by the government on a dressed basis at fixed prices. The dressing percentage was estimated by a farmer, feeder, or market man working for the government, and the price paid was on the dressed weight. If lambs were selling at about 30¢ a pound, our money, that meant 30¢ a pound carcass weight and it meant that the carcass weight was estimated as the live lamb reached the market. In no instance was a beef beast estimated to dress higher than 56 percent, so anyone that fed steers, or "bullocks" as they call them, to a degree of finish that would cause them to dress beyond 56 percent got nothing at all for the increased weight. Grain was not supposed to be fed to beef cattle. I saw quite a few big steers running on grass much as we see in the Flint Hills of Kansas and the Osage Country of Oklahoma. These appeared to be two, three and four-year-old steers. One might think that, with a shortage of meat, these cattle should have been slaughtered at a younger age. However, those of us familiar with fattening cattle on grass realize that it is very unusual for a steer that is less than three years of age to get in slaughter condition on grass. I have had a few people who do not understand the production of livestock ask why Britain cannot produce their own meat. When you realize the area of land available and further that it is necessary to feed forty-six million people, you will know that it is a physical impossibility.

A few of the things that impressed me particularly about the livestock in Great Britain are as follows: In the first place, I was amazed to learn that to date they have done very little to control tuberculosis and Bang's disease in cattle. One of the beef breeds has recently put into effect a regulation that any cattle coming into an organization sale must have passed the tuberculin test. However, in most of the sales, even the sale at Perth, this is not a requirement. So, cattle that react to the tuberculin test and those that have Bang's disease are brought together with the clean cattle at the average sale. That is the reason that most of the cattle selling for as much as 100 guineas are sold subject to re-test, and it is also the reason that we hear occasionally

in this country of some one purchasing a beast and not exporting him because he "failed the test." This lack of control of tuberculosis is not confined to beef cattle only, but is true of dairy cattle as well. Another thing of interest to me is that some of the old established breeds have reopened their registration books in order to include additional foundation animals. I am not sure of all of the breeds, but this is true of Shropshires, and with certain qualifications, it is true of Percherons. One other thing that is very apparent and about which most of you have heard is the amount of cross-breeding that is done in the production of commercial livestock. It seemed to me that most of the commercial ewe flocks were north country crossbreds. These were produced in Scotland and Northern England and were brought south to be used on the farms for commercial lamb production, much as we bring western ewes to the corn belt and farm sections of this country. Cross-breeding is practiced among the commercial cattle herds as well. One sees more blue-grey cattle in a week in England than he would see in years in the United States.

What about the future prospects for the production of livestock in Great Britain? The figures that I am about to give you are the figures that were published by the Ministry of Agriculture prior to the realization that there was a world wheat shortage. The same day that I read in the paper that the governments around the world, including our own, had over-night realized there was a shortage of wheat and rice throughout the world, I saw published information from the Ministry of Agriculture of Great Britain calling attention to the changes planned for the farmer.

> Britain's post-war farming program is a big one: To increase the livestock population by millions. The war-time urge was crops and more crops. Now the emphasis is to be on making good the appalling shortage of cattle, sheep, pigs, and poultry so that the nation may have more meat, milk, and eggs.

This quotation is sufficient proof of the fact that the decrease in poultry, sheep, and pigs was the result of the war conditions. The plan was to increase dairy cattle by 70,000; beef cattle 350,000; sheep 2,500,000; pigs 870,000; and poultry 8,000,000. The initiation of this plan was postponed for at least a year when the government was faced with the necessity of producing a larger portion of the food during the current year.

In summary let me say again, that there were decreases in certain classes of livestock due to the fact that this decrease was dictated by the necessity of the nation to survive. Let me remind you further that, as far as the farmers and leaders of agriculture in Great Britain are concerned, this decrease must, of necessity, be temporary only, and that the numbers of livestock must be increased. This will mean that when conditions are normal again the British

people will in all likelihood be depending on foreign sources for a large portion of their food, and that again rural England will return to diversified farming with livestock as the basis.

It is my personal opinion that the livestock producer, particularly the producer of pedigreed livestock in Great Britain, will continue to produce some of the best breeding animals that are produced anywhere in the world. They have an optimism concerning the future that is inspiring. They have confidence in their country and in their own ability to go ahead, and to maintain or improve the excellent quality that all know has existed for years in herds and flocks of Great Britain.

ANIMAL HUSBANDRY IN CONTINENTAL EUROPE[1]

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THE effect of the war on livestock production in Continental Europe is by no means uniform throughout the area. Generally, in the western countries, the Germans were not destructive of agriculture during their occupation, being very much concerned about producing large quantities of foodstuffs. They used organized controls for enforcing production and delivery. A war economy concerned with producing enough food to sustain a population over an emergency period encourages production of directly consumable foods. This means decreases in the types of livestock that are competitive for these foods. Therefore, the numbers of pigs and poultry decreased markedly whereas the numbers of cattle, horses, and sheep were reasonably well maintained. Invasions of Germans to the east were much more severe in their effects than invasions to the west. In those countries overrun by Germans and Russians, livestock populations have been very greatly reduced.

The policy of the Russians in their requisition and reparation demands has greatly reduced livestock populations in areas occupied by them. It has been most difficult to make observations in Russian occupied territory. Admittances were not specifically denied, but there was always delay and usually one was not able to leave the main designated highways.

The following estimates of livestock population in Germany for 1946 as compared with 1938 illustrate the situation that exists between the various zones and the consequent unrealistic impression conveyed when over-all livestock population figures are used:

Estimated Livestock Population in Germany by Zones 1946, in Percent Compared with 1938

	American	*British*	*French*	*Soviet*	*Total*
Horses	98	97	72	61	83
Cattle	92	80	46	60	73
Swine	39	40	30	33	37
Sheep and Goats	103	122	46	67	87
Poultry	55	34	50	38	41

The same type of situation prevails in Austria although that country supposedly is liberated.

The livestock disease situation in all European countries, measured by

[1] Presented as part of a symposium on "A World-Wide View of Animal Husbandry" at the opening session o the annual meeting of the American Society of Animal Production in Chicago on November 29, 1946.

U. S. standards, is bad. It is usual for 20 to 35 percent of the cattle slaughtered to show visible T. B. Belgium, Netherlands, France and Denmark are among the countries included in this statement. Foot and mouth disease is sporadic. Infectious abortion and mastitis are rather general.

The group of countries comprised of Poland, Hungary, Yugoslavia, Bulgaria and Rumania may at least partially be considered together. These countries produced some livestock surpluses prior to the war, but the combination of invading armies, requisitioning for feeding of troops and acquisition first by the Germans and later by the Russians of animals and foods for shipment to Germany and Russia, unsystematic land reforms, unstable political conditions, unfavorable crop years, and the requirement of adjusting acreages to expand production of oil seed and other critically required crops contributed to a bad situation and have certainly taken a heavy toll of their livestock industry.

Poland and Yugoslavia experienced greater losses than the others in this group. Some animals have since been sent into these countries by U.N.R.R.A. A large part of their income prior to the war was from the exportation of meats and fats. Their own exportations and the destruction and requisitioning by the Germans are the chief contributing causes to the Yugoslav situation.

Poland was severely depleted of its livestock, and, as in all Russian occupied territory, there is still a considerable amount of shifting and requisitioning. The fact that the boundary of the country has been changed adds to the difficulties. The numbers of livestock at the close of 1945 as related to the average for 1935–1937 indicated that there were about 27 percent of the horses remaining, 31 percent of the cattle, and less than 15 percent of the hogs. This was a country of small farms, individually owned, with emphasis on livestock. Prior to the war, the income from livestock ran about 70 percent of the total for agriculture. Polish agricultural experts state that, whereas they were formerly self-supporting with slight surpluses, they now must import basic foodstuffs due to reductions of the fertility of the soils, which in turn were due to the reduction of livestock and consequent loss of manure.

There is probably little value to individually discuss other countries in this group. Hungary, Rumania, and Bulgaria have fared somewhat better; Czechoslovakia much better; Greece very badly.

Italy, having thrown in with the Germans, had livestock inventory increases through 1942, but there were some decreases afterward. Her 1946 inventory shows about 80 percent as many cattle, swine, sheep and horses as in 1942. The Italians have produced some excellent oxen and other cattle suitable for their climatic conditions. However, much of their other livestock

is inferior as measured by standards of some of the other European countries.

In Norway, all cattle are of dairy type. Cattle account for 50 percent of the agricultural annual income. The quality of their cows did not deteriorate during the war. Numbers decreased about 14 percent, but they have already again increased 4 percent and their shortage will be overcome within two years. Sheep numbers are higher than before the war. Hogs suffered a decline of 35 percent. Horses increased during the war period. Some of these were sold to U.N.R.R.A. since the close of war. Self-sufficiency is the aim of Norway though some bacon, butter, and eggs were exported.

Since Sweden was not invaded, their livestock population was not materially affected. The livestock pattern is dairy cattle and pigs, much as in Norway and Denmark.

In many respects Denmark may be taken as the model for a livestock producing country. Fifty years ago they had one cow on every four and one-half acres, now they have one cow on every two and one-half acres. They have two breeds, the Red Danish and the black and white Jutland. Most of the cattle belong to the Red Danish breed. Seventy percent of the herds have less than 15 cows each. The producers are well organized into cattle breeding societies. The Danish were probably the first people to breed for performance and not for points, though they do score their animals based on inspection at the shows. Before the war, they had milk records on 40 percent of their cows. The average life of the cows is about 4.5 to 5 lactations.

The Danes have had a most intelligent program in connection with producing bacon for the English trade. Their testing stations and bacon factories and the general activities of their breeding societies have been widely discussed in this country. In 25 years they reduced the age of their slaughter pigs from 210 to 177 days and the amount of food used per kilogram increase in live weight from 4 to 3.4. At the same time they have increased the percentage of export bacon to live weight and have definitely increased the length of the bodies of the pigs. There is much uniformity in the feeding of their pigs. This business is based to a great extent upon the by-products of their dairy industry, together with imported grains.

The sheep business in Denmark is not important, though it increased some during the war.

For the war period 1938 to 1945, horses in Denmark increased 6 percent, cattle decreased 12 percent by 1942, but in 1945 were only 1 percent below pre-war. Hogs fluctuated a great deal. They declined 38 percent by 1942, rose to 65 percent in 1943, fell to 53 in 1945. Pork production is now stabilized on the basis of domestic feeds which means about 50 percent of pre-war. Denmark was the only continental country which had agricultural surpluses at the close of the war.

Livestock hold a very important role in the agriculture of the Netherlands On the basis of a long-time trend covering 80 years, there has been a decline in sheep. Horses came up about ⅛ up to twenty years ago with no change since that time; cattle have doubled; hogs have increased five times; poultry fourteen times.

Cattle are easily the most important branch of the livestock industry in the Netherlands, and dairying is the chief activity. There is very little cattle fattening. There are three breeds, with the black and white Friesians easily the most important. The average milk yield is higher in the Netherlands than in any country in the world (770 gal.). It is a business of small producers with few farmers having more than four or five cows. Cattle are stall-fed for six months of the year. The preponderance of production comes from the use of pastures and roughages though they estimate the need of 1000 pounds of cake per cow per year.

Pigs are produced largely on skim milk, whey, potatoes, and rye. They are subject to about a four year cycle just as they are in other countries, including Denmark. They cater to fat pork production at home, but they have tried to feed some pigs for the English bacon trade. While they had some success, production was mostly on a home basis requiring heavy hogs averaging over 350 pounds.

A comparison of the Netherlands and Denmark is that in the former there is a larger population trying to make a living out of fewer livestock on ⅔ as much land, much of which is only suitable for permanent pasture. Naturally, there is less prosperity. The war was harder on the Netherlands than Denmark. Comparisons of 1939 and 1946 populations in the Netherlands show a cattle decrease of 18 percent; horse increase 8 percent; sheep increase 50 percent; hog decrease 42 percent; poultry decrease 70 percent.

The problem of Belgium has been one of feeding her industrial population. This has been an outstanding influence in determining the characteristics of the livestock business. It is a home market business which has not led to uniformity in marketing, in processing nor toward much cooperative effort. In Belgium there is a great interpenetration of agriculture and industry which is advantageous for both the worker and industry. Belgium, unlike Denmark and the Netherlands, has a considerable amount of mountainous terrain. Only 61 percent of the total land area is agricultural land. The individual holdings are extremely small and frequently the situation is aggravated by the fact of land parcelment or strip farming. Farming depends less on livestock than is the case in the Netherlands or Denmark, but nevertheless it is claimed that livestock and livestock products formerly accounted for ¾ of the value of all agricultural output.

The number of horses reached their maximum in 1914. There was a

tremendous decrease during the first world war. The business was built back some afterward, but on account of the reduced exportation demand, horse production has made no progress in many years. Sheep also have remained practically constant for 30 years. Cattle have increased only about 25 percent in 60 years. At the same time, they were doubling and trebling in the Netherlands and in Denmark.

Cattle are dual or triple purpose in type. There are five breeds of cattle with some sub-types. This number has been an obstacle to improvement. They have three kinds of cattle societies: breeding societies, bull clubs, and over-all management associations. The Belgians formerly produced heavy hogs, but now are selling at weights that run from 200 to 240 pounds. War changes in their livestock numbers were not great.

The Belgian ministry estimates that ⅔ of the herds are affected with T. B. and that 20 percent of all cattle would react to T. B. tests. A contributing cause to these conditions is the unhygienic situation under which small farmers keep their animals.

France is an agricultural country, proud of her peasantry. The French have centered their economy on self-sufficiency in which they exported only about 6 percent of their agricultural output, but at the same time, kept out foreign food with a protective tariff. There are a wide variety of soils and climates. Much of the land is poor. Of the total land area, 63 percent is in agriculture and 20 percent in forests. Nearly 3/5 of the land in the south is under grass, whereas less than ¼ is under grass in the north. The livestock industry is not on a particularly well-organized basis. French people do not practice very much cooperation. Peasants object to having anyone pry into their stables or affairs.

There are very many breeds of cattle in France. In some sections, such as the Pyrenees, there is almost a breed to each valley. There are probably a dozen breeds of prominence, among which can be included the Friesians, Bretonne, Charolaise, Limousins and the Normands. Cattle breeding has developed slowly. The French, like the British, have preferred to judge excellence on the basis of points of external appearance rather than on the hard facts of performance. France eats much veal, but there also is a cattle feeding industry which includes summer fattening on grass and winter feeding connected with the sugar beet farms. Some of the most progressive farmers are those of Normandy, which district is also the most advanced in dairying. The average milk yield in all France is low. Milk records are available on less than 1 percent of the cattle. Stabling generally is bad.

Sheep represent an important industry in France. There are very many breeds, of which I was most impressed by the Iles-de-France. The numbers have declined through the years for various reasons, probably the most im-

portant being that France imports 90 percent of her wool. This means that they cannot afford to protect the price of domestic wools. The people eat much mutton and lamb. Pig production is found everywhere, but the output is largely consumed locally. Over 40 percent of all pigs are killed on the farms where they are produced. Pigs, generally, are raised in sties on scraps and refuse. While this is the general situation, there are many notable exceptions. As in Belgium, the number of horses reached a peak in 1914, dropped enormously during the first world war; were built back to another lesser peak about 1930. They were on the decline at the beginning of the last war. Again there is a great variety of breeds. The government has taken much interest in horse breeding and their inspections and distribution of stallions could be taken as a model. The Percherons developed for the American trade, just as to a considerable extent was true of the Belgians, were quite a different type than that advocated for and used by their own farmers.

War influence on livestock populations in France, as indicated by comparisons of numbers in 1938 and 1946, show that cattle decreased 6 percent, sheep and swine decreased 33 percent, and horses 7 percent.

Switzerland is a country of 25 independent republics and three languages. One fifth of the population is engaged in farming. There is very little poverty in Switzerland and the diet of the people is excellent. The Swiss long ago found milk production the most profitable method of utilizing grass. The dairy business is long established. Sixty years ago Switzerland had forty cattle per 100 acres of agricultural land. Her average production per cow was 500 gallons when the Danes were still at 250. Switzerland has an international reputation for livestock breeding. Therir cattle are popular all over Europe and exports have gone to many countries. There are virtually only two breeds, the Brown Swiss (Schwyz) and the Simmental. The former is well-known in this country, but we do not know so much about the latter. The Simmental are buff and white dual, or actually triple, purpose cattle bred chiefly by small scale farmers. They are very large, thrifty cattle with much to recommend them. Many are found in Austria, Germany, Southern France and Northern Italy.

The Swiss have 1500 local cattle breeding societies with about 50,000 members. The government subsidizes cattle breeding and milk recording. Methods of feeding vary a great deal from extremes where cattle are stabled practically the entire year to a situation where they graze in the Alps six months and are wintered almost exclusively on hay. Diseases are less of a menace than in most other areas. They are doing systematic work toward disease control and elimination. Great stress is placed upon health and thriftiness of the animals in their breeding program.

The pig population in Switzerland has more than doubled since World

War I, largely because of favorable prices. Even with the skim milk and whey available, pigs are still dependent on imports for about $\frac{2}{3}$ of their food. The government has been active in encouraging potato growing and improving pig production. The market is generally for light pigs weighing about 180 pounds. Not much mutton is eaten and only five per cent of their wool is home raised. Numbers continue to decline. Horse breeding formerly flourished and the Swiss furnished horses to most of southern Europe. This business diminished as dairying increased.

Feed, and not war directly, affected Swiss livestock populations during the past few years. Hogs were reduced materially, other classes changed less than 10 percent.

Germany, being a large country made up of Prussians, Rhinelanders, Bavarians, etc., has a wide range of characteristics. Industry has dominated her economics while agriculture has been considered in terms of what was desirable from a security viewpoint. The agriculture was a home market business, largely protected from foreign competition.

There are many breeds of cattle in Germany, but two are most important. These are the black and white Lowland, which is about the same as the Friesian, found all over northern Germany, and the buff and white type of the south that is related to the Simmental. About $\frac{1}{4}$ of all cattle are used for work as well as for milk production, hence, the average production figures are not high. There was very little specialized beef production.

The pig was the chief meat-producing animal in Germany, and has provided $\frac{2}{3}$ of the meat requirements. It was largely a business of small producers. A very wide use has been made of potatoes in the production of hogs. After World War I, horse numbers were very low and these numbers never fully recovered. The Germans were doing a great deal of mechanized farming, because they did not believe in the economy of the horse. There has been a heavy decline over a long period in sheep. The Nazis tried to increase the number of sheep so that Germany would not be so dependent on wool imports. They experienced some success in this program.

The zonal and war influences have been mentioned. Much of the same is true of Austria as has been indicated for Germany. However, the Pinzgau as an important dual purpose breed of cattle should be mentioned as a contribution of the Austrians.

The Governments of Continental European countries have been aware of the importance of livestock production and in the past have provided subsidies and maintained many livestock breeding stations for the production and distribution of improved types of animals.

Europeans universally recognize the important relationship between livestock and the fertility of their soil. Many times one will hear the state-

ment that more cattle are needed because they need more manure. I have indicated in several cases the high percentage of the total farm income which comes from livestock and livestock products. Cattle are especially important because they furnish milk, meat, power and fertilizer. The people are realistic and the types of livestock they have produced serve their purposes very well. The highly specialized beef cattle of the United States have no counterparts on the Continent, and I see no place for them in their economy. Some of their breeds might well be considered for possible use in areas of the United States in addition to those notably from Denmark which we are already including in our U.S.D.A.-sponsored breeding programs. The Ile-de-France sheep is an excellent breed. Simmental, Charolaise, and Norman cattle and possibly some Italian race such as the Romagnola have characteristics that offer possibilities. Europeans farm intensively. Their holdings are small, and production per acre is high but per man it is low. They stable their animals a great deal, and use roughages to the maximum. Staking animals, also cutting and feeding fresh roughage as soilage, are common practices.

Research is highly appreciated in all European countries and their experiment stations are being put back into operation, but the war and occupation leave a gap. Top notch personnel is at an all time low. Their research work is generally thorough and they strike toward fundamentals though there are many units which are of more or less demonstration types in which they stress application to immediate production problems.

There were many schools for young farmers. Most of these were part-time and might be classified as on-the-job training. University training of personnel for agriculture was thorough but it was not intended to be mass production.

Personnel corresponding to our extension field workers were engaged more in control than demonstration or education. Germany had the most complete organization of controls extending to every farm and every commodity in terms of acreages, crops, and required deliveries. As related to livestock, this accounted for encouraging milk and discouraging pigs and poultry which were more competitive for foods needed for direct use by the people.

Much of the animal husbandry of the U. S. A. has been developed from a British pattern. It is constructive that we appraise the situation and the possible contributions of other areas as is now being done.

We still have many areas in the United States for which our breeds and methods of production do not approach adequacy. A constant search, with open minds, over the entire world for ideas or animals is always to be commended.

ANIMAL HUSBANDRY IN AUSTRALIA[1]

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I APPROACH this subject with deep gratitude that no one in the American Society of Animal Production expects me to cover it adequately. It is a subject as wide as Australia's acres. I should like deliberately to arouse your sympathy by asking you how you would feel if you were requested to prepare a short paper on "Animal Husbandry in the United States." All you could do would be to hit a few high spots and speak in broad generalities, knowing that nearly every statement you made might be true of some sections and not of others. Australia and the United States are almost identical in size and Australia's diversity of climate and topography is almost as variegated as our own.

Compared with the United States, Australia is a poor country. Lack of water is the main reason for her relative poverty, rather than inherently poor soil. Rivers and creeks that reticulate nearly all America are sadly lacking in Australia. Vast irrigation projects, so common to our West, are impossible there at present and deep wells often are disappointing when they yield water at a temperature of about 150 degrees that is heavily impregnated with salt. In our country we have occasional droughts but they are seldom serious and almost never have a drastic effect on the national economy; in Australia rainfall in the agricultural areas is always uncertain and all too often does not come at all. In such times the national economy may be severely affected. Animals die by the millions, the wool clip is reduced in weight and value and every Australian suffers directly or indirectly. At such times all hands on the ranch or "stytion" as the Aussies say, may turn out to skin the dead animals and salvage the hides. Even the native kangaroos may die. If the stock can be moved (and often they cannot) they may be sold for a mere fraction of their value and taken by someone whose lands enjoyed a rain. I recall a wool grower in the state of South Australia who at the time of my visit had already lost 50 percent of his lambs through drought and said if it didn't rain within 3 weeks, he would lose the remainder. It didn't rain and I presume he lost them all. Such instances are commonplace. They cannot be averted because in a large proportion of the country growers are dependent on natural feed. Rainfall is such a precious commodity that stock men always speak of getting so many "points" on their properties, a "point" being one one-hundredth of an inch in the ever-present rain gauge.

[1] Presented as part of symposium on "A World-Wide View of Animal Husbandry," before the American Society of Animal Production in Chicago, Ill., on November 29, 1946.

My first visit to Australia was during a drought. It was not a terribly severe one but just the common or garden variety. Its effects were greatly mitigated by the fact that the previous season had been an unusually good one and there had been an abundance of dried grass. Yet even in this drought which was not to be compared with that of 1944–45, I saw sheep eating the burrs from each others' sides and backs to keep alive. Signs on the bathroom doors of the hotels in the affected area asked the patrons not to use more than 4 inches of water in the tub. Under such conditions the odor of sudoriferous exudate may be considered a sign of patriotism. Of course it must not be implied that national droughts are the rule. If they were, the Commonwealth would fold up. But it is true that drought strikes some portions of Australia with monotonous regularity and visits a substantial part of the productive areas of the Commonwealth too often for the security and peace of mind of producers. The lack of water will probably prevent Australia from ever having a density of population comparable to ours.

Despite the vicissitudes of Jupiter Pluvius, Australia is primarily an agricultural country in which animal husbandry is the most important business. Within the field of animal husbandry the sheep business is of paramount importance and within the sheep business the production of wool is nationally far more important than the production of fat lambs. The importance of sheep is so great that on the face of the commonest coin, the one shilling piece, the Australian sees the head of a Merino ram, put there to remind him that his welfare is linked with the sheep industry no matter what his occupation.

Considering the whole continent as a unit, feed conditions are such that only the Merino, the world's toughest domesticated mammal, can thrive. In the better areas, principally a narrow strip running north and south and lying just over the Blue Mountains that fringe the eastern coast, a higher rainfall has permitted development of seeded permanent pastures. Along this strip Corriedales, Romneys, and crossbred Border Leicester X Merinos are found in addition to stud flocks of Southdowns and several other breeds. It is probably the most productive livestock area in the Commonwealth, but it occupies too small a proportion of Australia. It is principally in this strip that fat lambs can be produced.

According to Dalgety's Annual Wool Review, 85 percent of all the sheep in the Commonwealth in 1935 were Merinos. In 1945 this percentage had declined to 76 percent. Undoubtedly the decline has been influenced by the development and improvement of pastures in the better areas, permitting the use of breeds that do not have to hustle their living from an unbountiful nature. But even in this area, the Corriedale and the Border Leicester cross predominate, both of them carrying 50 percent of Merino blood. The influ-

ence of the Merino is so great that any sheep of any breed other than a straight Merino is called a crossbred and all wool not of Merino origin is called crossbred wool.

The human population of Australia is around 7½ million. The sheep population is usually from 100 million to as high as 127 million depending on whether the count is taken following a series of good years or a bad drought. Assuming a normal count of 120 million, the average citizen of the Commonwealth owns 16 whole sheep while the average American owns about .28 or one hind quarter of one animal. Of course both figures are oblivious to a high standard error of the mean.

While nearly 80 percent of all the sheep in Australia are Merinos, these are not all the same kind. The Australians have developed three different strains or families of Merinos: the fine wool type carrying fleeces that grade finer than 64's, the medium wool type with fleeces that average 62/64's and the "strong" wool type grading 58/60's. The medium type wool is by far the most popular and most of the record prices are paid for rams of that strain. Strong wool Merinos are dominant in the salt bush areas, principally in South Australia. They are the largest bodied and the heaviest shearing Merinos in the world. Fine wool Merinos produce some of Australia's highest priced and most famous clips but the average fleece weight is so low that it is not usually compensated for by the premium prices paid for the wool. During recent years these fine wool or "Tasmanian" Merinos have lost ground to the larger, smoother and heavier shearing sheep found among the other two Merino families.

Any herd or flock of purebred animals in Australia is called a stud and the breeders are called stud masters. Sheep breeders sell their best animals as stud rams; the remainder, corresponding to our range rams, are called "flock" rams. In contrast to our own buying habits, the Australian pays less for flock rams than we pay and much more for good studs. Comparable prices are difficult to determine because price is or should be more closely linked to buying power than to rates of exchange and the Australian lives much more cheaply than we. However, using the rate of exchange as a basis for comparison, Merino flock rams bring around $20 to $35 each while really good studs produced by the same breeder may sell for $700 to $2000 or more. In the United States breeders of purebred livestock seldom make a great deal of money. In Australia the Merino stud masters of national repute may make a great deal. This leads to competition of cut-throat style, the establishment of many studs and the most meticulous care in guarding an established reputation. I do not have a recent directory of breeders but a few years before the war when times were normal, their directory showed nearly 400 studs of Merinos alone. It is of great interest to us to know that some of

the most famous ones have been closed to the introduction of outside blood for over half a century.

In the United States we have had for many years a great demand for lamb, causing our Merinos and particularly our Rambouillets to be selected primarily for conformation. Our outmoded and wholly archaic system of marketing wool has given little incentive to our breeders to produce a superior fleece and many of them do not even know a good fleece when they see one. We have, however, largely achieved our goal on conformation and our best Rambouillets, which are pure Merinos, are the best conformed and the most rapidly maturing Merinos in the world. The Australian who runs Merino sheep usually produces no fat market lambs whatever. He is primarily in the business of growing wool for an exacting export trade. Faults such as cow hocks, sickle hocks, narrowness between the legs both fore and aft do not disturb him much if the animal has a good fleece. As a result of this attitude, the Australian Merino of any of the three strains is at least as superior in fleece as ours are in conformation. I have previously mentioned that the South Australian strong wools are the world's heaviest shearers. On one property in that state I saw shorn a group of about 25 stud rams of mixed ages kept as sires on the property. The entire lot had been heavily bred to as many as 100 ewes during the season and had not been housed. They averaged 31 pounds of wool. The highest fleece weight was 38 pounds. This wool had a shrinkage of just over 50 percent, making a calculated average clean scoured weight of about 15 pounds. Such weights are unheard of in this country. The same breeder had a band of 1000 wethers that averaged 22 pounds in fleece weight. They had been run on salt bush in a country that supports only 20 sheep to a square mile.

While the standards of these breeders are very rigid, they have been a most potent factor in making the Australian clip the world's best. If any woolgrower is careless in growing his clip or in preparing it for market he gets it squarely in the neck when his wool is sold at public auction. He may live in a house that is not very good even by our standards of homes for poor professors, but he will probably have a shearing shed that cost more than his house.

Fat lambs are produced only in certain areas favored by better than average feed. Most of them are out of Border Leicester X Merino crossbred ewes and sired by Southdown rams. They are primarily for export, the Australian palate preferring mutton which is a staple. Most of the stations I visited were devoted to sheep. It was but natural that on these properties mutton is an overwhelming favorite. The best available statistics show, however, that the per capita consumption of beef is slightly larger than of mutton. The export lambs produced are beautiful. The British housewife demands a small

roast and the lamb carcass, to meet this demand, must weigh around 28 to 36 pounds. Such weights mean 55 to 70 pounds live weight, or about 25 pounds lighter than our American producers hope for.

A survey of the parasites and diseases that the Aussie contends with shows almost the entire catalog. Most of them are not serious. The outstanding exception is the blow-fly which annually costs millions of pounds to combat and causes the death of many sheep. Although a great deal of thought has been put into control measures, the problem is yet far from satisfactory solution.

The Australian's greatest predator is the rabbit. Introduced to afford sport, the rabbit found the wide open spaces so much to its liking that its reproduction reached astronomical figures. At one time it was actually a serious question as to which would survive, the man or the rabbit. Five rabbits eat as much grass as one sheep, according to Australian calculations. The problem has never been wholly solved but by heroic means it has been mitigated. There are now about 250,000 miles of rabbit proof netting fence in the Commonwealth. Professional "rabbiters" gŏ about with packs of hounds; rabbits are trapped, shot, and poisoned, but still they breed. In 1945 from Melbourne alone over 4 million pounds of dried rabbit skins were sold, a large proportion of them to the United States for making hats.

While the Australians are the master breeders of the world's wool, their beef cattle are disappointing. The latest census showed about 9 million head. Each of the three principal breeds has many adherents although both black cattle and Shorthorns are relatively more popular than in the United States. The business of taking feeder calves and turning out grain-fed baby beef is virtually non-existent. Theirs is a grass-fat industry. Steers are kept until they are 3 or 4 years old and sent to market looking very heavy in the neck and forequarters and about half done. Beef cattle can withstand better than sheep a combination of high temperature and humidity. This fact is responsible for a wider distribution of cattle over the northern rim of the continent where few sheep are run. But along this northern rim lying in the tropics, Brahma cattle and Brahma crosses with British breeds are becoming popular.

There are about 4 million dairy cows or about half a cow per person as compared with a fifth of a cow per person here. The industry is largely confined to coastal areas. About 190 million pounds of butter are exported. The nature of the country, its wide expanse, the relatively poor rail and road communications combine to make the Jersey the most popular breed. The small, beautiful, Island type is preferred.

I saw only one herd of American type Jerseys and it was owned by a college. The superintendent said the Jersey breeders who had seen them considered the herd a disgrace to the Commonwealth and some insisted they

should be slaughtered. The college had no intention of slaughtering them since about 40 percent of all the record producing Jerseys in the country were then in that small herd of less than 20 cows. Such an attitude on the part of a fraternity of breed enthusiasts is not an Australian invention; unfortunately the same idea is all too prevalent in the U.S.A.

Pork, which the Aussies call "pigmeat" is not popular. They consume only about $\frac{1}{8}$ as much per capita as Americans. The government has tried to stimulate interest in pork production and with some measure of success but the pig is still a fugitive from wide popularity. The cause is probably more closely related to supplies of concentrates and to the prevailing general type of agriculture than to any aversion to taste.

Draft horses are used much more than in the United States but the record shows their numbers are rapidly declining. The reason is the same one that it is elsewhere—the tractor. The Clydesdale is the dominant breed and Australia has good ones.

Light horses are almost a fetish. Give an Aussie a chance to see a horse race and he will probably be there even if he has to close up his store or play hookey from his mother-in-law's funeral. The pari-mutuels are played by everyone from the premier to the janitor. A big racing meet in a metropolitan area may seriously interrupt business. This would be denied by an Australian because, to him, *business*, at the moment, is the races. It is not at all uncommon to pick up a city newspaper and find the world's news packed into two pages with the next four devoted to "rycing". The quality of these horses is as high as can be found anywhere.

The Government maintains a college of agriculture in each of the important agricultural states. While all of these are tuitional schools, they are partly subsidized by government and the tuition is low. Indeed the total cost of attendance is far less than the cost of board and room at an American institution. As far as I could learn all of these colleges are run on a somewhat similar pattern. At each of the three leading ones that I visited, the enrollment was from 60 to 125 students, of whom from a dozen to twenty were working for degrees. The remainder were two and three year students working for diplomas but not degrees. The two and three year students attend formal classes only half a day or in some cases three days a week. The other half of the day or week is spent in work on the college farm. Each department of the farm has an overseer whose duty is to instruct the student in proper handling of the livestock, machine, crops, or construction. These students are in attendance, at least so far as farm work is concerned, nearly the year round. Vacations are short. Thus at the end of two years the graduate has no need to look for a job that will give him the practical experience necessary to be a farmer. He actually *is* a farmer. He has done a fair amount of every

kind of work an Australian farm will require of him. He can not only harness horses three and four abreast; he can operate properly the machine they are hooked to, completely rebuild the harness if necessary, and repair the machine if it breaks. He can build forms, mix and pour the concrete for small farm structures, run a milking machine, shear sheep, grade a small wool clip and care for any kind of livestock or crops. His time is so fully occupied it is perhaps fatuous to remark that his college has a poor football team, if any at all. His principal contact with the rah-rah aspects of college life is cricket on Sunday afternoon with a jolly cup of tea at half time or a corking tennis match.

A degree student in agriculture at an Australian University is presumed to be preparing himself for investigational or regulatory or other comparable work. In his first year he takes Chemistry, Mathematics, and other basic subjects just like an American boy. In his second year he may go to work as a laborer on an agricultural college farm and take a mixture of course work and practicum. Then he goes back to the University for two more years. If he is to be a research worker, he will probably go abroad, usually to England for an advanced degree. Some of the agricultural colleges are separate from any University but an agricultural college graduate with a diploma for 3 years work may be admitted to a University and given part credit on the strength of his diploma. Thus a diploma in agriculture is not a degree. The practical instruction given all students in agriculture is something most of us would wish for our own institutions. However, it is made possible only by very small enrollments.

Australian agricultural research is conducted partly by agricultural colleges, but a large part of the best research is done by the Council for Scientific and Industrial Research. This is a Commonwealth set-up, so organized that its personnel may utilize land and facilities of the colleges and other public agencies. The bulletins and publications of C.S.I.R., with which most of us are familiar, are testimony to the high caliber of most of the work it does. and of the men who do it. Australians have reason to be proud of the organization.

Agricultural extension in Australia is very poorly organized, so poorly in fact that the average farmer is hardly aware of its existence. The result is that the investigational work of the colleges and the Council for Scientific and Industrial Research has a hard time finding its way to the man on the farm. However, there is ample evidence that many investigators are aware of the situation and no doubt it will be corrected.

NEWS AND NOTES

The next meeting of the American Society of Animal Production will be held at the Hotel Sherman in Chicago on November 28 and 29, 1947, with a dinner for the honor guest on November 30. Abstracts of papers to be presented at this meeting must be in the hands of the Secretary, Dr. W. G. Kammlade, by September 10. Members are reminded that abstracts must not exceed 250 words in length, that they should be typed (double spaced), and the ribbon copy submitted. The lines should be numbered in the left-hand margin. Abstracts must be summaries of results and conclusions, and members should consult previous issues of the JOURNAL and have their abstracts typed in a form corresponding to that used in these published abstracts. For information concerning chairmen of Sectional Programs at the next annual meeting, members are referred to page 103 of the February 1947 issue of the JOURNAL OF ANIMAL SCIENCE.

Nominations for the Morrison Award must be received by the Secretary of the Society, Dr. W. G. Kammlade, before June 15, in order that they may be considered for the second annual award which will be presented at the forthcoming annual meeting. Rules concerning the Morrison Award were published on pages 236 and 237 of the May 1946 issue of the JOURNAL OF ANIMAL SCIENCE.

The Executive Committee of the Society has selected Dr. George H. Hart, head of the Department of Animal Husbandry at the University of California in Davis, as the honor guest for 1947.

The Western Branch of the American Society of Animal Production will hold its next meeting at the University of California in Davis on August 27 and 28, 1947. This will be a joint meeting with the Western Division of the American Dairy Science Association. Papers from members are invited and material of general interest to the two groups is especially solicited. Abstracts of papers to be presented should be submitted to Prof. S. W. Mead, Animal Husbandry Division, University of California, Davis, California, not later than June 1.

A book entitled "Feeds of the World—Their Digestibility and Composition," has been published recently under the authorship of Burch H. Schneider, of the Animal Husbandry Department of the West Virginia University. It contains the most comprehensive compilations available on the composition and digestibility of livestock feeding stuffs, and will be of major value to all workers in the fields of animal nutrition and livestock feeding.

W. E. Carroll, Head of the Department of Animal Husbandry at the University of Illinois, has been appointed Associate Director of the Agricultural Experiment Station at that Institution.

J. O. Halverson, of the Department of Animal Husbandry at North Carolina State College, has retired after 26 years of service.

George H. Wise, formerly of the Dairy Husbandry Department at Kansas State College, has accepted an appointment as Associate Professor of Dairy Husbandry at Iowa State College. Dr. Wise will devote the major portion of his time to research, primarily on physiology and biochemistry of nutrition of dairy cattle.

E. B. Forbes, retired on July 1, 1946 from the post of Director of the Institute of Animal Nutrition at the Pennsylvania State College. He now has the rank of Professor Emeritus.

Elroy M. Pohle, formerly of the Western Sheep Breeding Laboratory, Dubois, Idaho, is now with the Wool Division, Livestock Branch of Production and Marketing Administration, Washington, D. C., where he is Chief of the Standards Section for wool and mohair.

Fred F. McKenzie has been appointed Head of the Animal Husbandry Department at Oregon State College. He replaces Ray G. Johnson, who resigned to accept a position with the American International Association for Economic and Social Development with headquarters in Caracas, Venezuela.

L. L. Rummell will become dean of agriculture and director of the agricultural experiment station, Ohio State University, September 1, succeeding respectively John F. Cunningham and Edmund Secrest, who will retire.

Clarence Dorman, director of the agricultural experiment station at Mississippi State College, died suddenly in February.

Roger B. Corbett resigned as secretary-treasurer of the American Farm Bureau Federation, and on April 1 became associate dean and associate director of extension, College of Agriculture, University of Maryland.

J. C. Miller, head of the Animal Husbandry Department, University of Tennessee, has resigned to become head of the animal husbandry department at the Texas A & M College, which now includes both teaching and experiment station work, effective May 1.

Ralph E. Hunt, head of the animal husbandry department at Virginia Polytechnic Institute, has been granted one year's leave of absence for service with a special agricultural commission employed by the Syrian Government.

L. J. Horlacher, assistant dean, College of Agriculture, University of Kentucky, is now on sabbatical leave and taking special work in administration at the University of Chicago.

J. P. Sackville, head of the Animal Husbandry Department, University of Alberta, Edmonton, Canada, has been appointed secretary of the Canadian Aberdeen-Angus Breeders' Association with headquarters at Calgary, effective July 1.

Charles L. Harlan, in charge of livestock and poultry statistical work in the Bureau of Agricultural Economics, USDA, retired February 28 after more than 26 years of government service.

Andrew M. Boss of the University of Minnesota passed away recently.

Everett T. Benton, extension animal husbandman, Michigan State College, died suddenly on April 22, following a major surgical operation.

L. P. McCann, extension animal husbandman at Ohio State University for the past 19 years, resigned to accept the position of field representative for the American Hereford Association in the East North-central Area, effective April 15.

Paul A. Gantt, extension animal husbandman, University of Hawaii, resigned that position on January 31 to take over operation of an 850 acre plantation which he purchased near Rosedale, Louisiana.

David H. Williams, former county agent in Sauk County, Wisconsin, is now in charge of swine improvement for the Wisconsin Agricultural Extension Service, succeeding T. E. Hamilton, who resigned.

Lowell E. Walters, formerly on the animal husbandry staff at Massachusetts State College, has joined the animal husbandry department at the Oklahoma A & M College.

Byron E. Colby, graduate of the University of New Hampshire and former county agricultural agent, has been appointed extension animal husbandman at Massachusetts State College to succeed C. J. Fawcett, who recently retired.

Ben Morgan, former county agricultural agent at large in the West Virginia Extension Service, was made assistant extension animal husbandman in the same organization, effective February 1.

George W. Gibson, former extension animal husbandman, University of Georgia, recently resigned to become field representative of the Georgia Aberdeen-Angus Breeders' Association.

J. R. Sprengle, extension animal husbandman in the Colorado Agricultural Extension Service, has resigned to become field representative of the American Hereford Association, with headquarters at Denver.

W. W. Garth, Jr., has been reappointed as specialist in Mohair and Wool Marketing with the Extension Service of the Texas A & M College, after a period of war service.

George R. Johnson, extension animal husbandman at Cornell University, was on sabbatical leave during recent months, taking graduate work at Michigan State College.